REGIONAL ANATOMY

IN ITS RELATION TO

MEDICINE AND SURGERY.

BY

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ILLUSTRATED FROM PHOTOGRAPHS TAKEN BY THE AUTHOR OF HIS OWN DISSECTIONS, EXPRESSLY DESIGNED AND PREPARED FOR THIS WORK, AND COLORED BY HIM AFTER NATURE.

"L'anatomie n'est pas telle qu'on l'enseigne dans les écoles."—BICHAT.

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TO THE MEMORY

OF MY FATHER,

JOHN H. B. McCLELLAN, M.D.,

AND OF MY GRANDFATHER,

GEORGE McCLELLAN, M.D.

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REGIONAL ANATOMY.

REGIONAL ANATOMY

IN ITS RELATION TO

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THE REGION OF THE ABDOMEN.

In every-day practice the physician or surgeon may be called upon to distinguish by palpation or percussion the condition of the organs concealed beneath the abdominal parietes, and therefore a knowledge of the normal relations of the viscera within this region to one another and to the surface of the body is of primary importance as an aid to diagnosis. As these relations can be properly appreciated only when the special anatomy of the abdominal wall and the viscera is understood, the subject will be here first treated by describing these structures and organs as they are revealed by systematized dissections.

The superficial appearance and degree of prominence of the abdomen vary with the age and the general development of the individual. In young children the abdomen forms a marked protuberance, owing to the comparatively small size of the pelvis, so that the bladder and the upper portion of the rectum are crowded into the lower part of the abdominal cavity, while the liver, which is relatively very large, often extends across the upper part, completely overlapping the stomach (Plate 66, Figs. 1 and 2).

In the well-formed adult male the surface of the abdomen is irregular,

the depressions corresponding to the tendinous intersections being strongly contrasted with the bulging of the fleshy parts of the muscles (Vol. I., Plate 27). The most conspicuous of the surface-depressions are the *median furrow*, which extends from the ensiform cartilage to a point midway between the umbilicus and the pubes, and the *right* and *left lateral furrows*, which curve slightly from the tenth costal cartilages along the outer borders of the recti muscles. The median furrow corresponds to the subjacent linea alba, and the lateral furrows to the lineæ semilunares. When the body is erect, the recti muscles usually present two uniform masses situated between these furrows; but when they are brought into action by bending the body forward or backward, three transverse furrows are produced on each side, the upper one of which is at the cartilage of the eighth rib, and the lower one at the umbilicus, while the middle one appears midway between them. They refer to the lineæ transversæ or tendinous intersections in the recti muscles. When there is much subcutaneous fat there are two flexion-folds noticeable in the skin, one at the umbilicus and the other two and a half centimetres, or about an inch, above the pubes. The latter corresponds topographically to the top of the bladder when ordinarily distended.

The *skin* over the front of the abdomen is more adherent to the subjacent parts in the middle line than elsewhere, and is most loosely attached in the region of the groin on each side (page 83). Above the umbilicus the skin is delicate and sensitive. In the male it is provided with fine hairs, which are directed downward and inward and are coarser in the middle line, where the color is usually darker. In the female the hairs are confined to the integument surmounting the pubes. There are comparatively few sebaceous and sweat glands. After distention from ascites, ovarian tumors, or pregnancy, the skin over the lower portion of the sides and front of the abdomen presents white depressed streaks, called *striæ gravidarum.*

The umbilicus, or **navel,** is the cicatrix resulting from the obliteration of the umbilical cord at birth, and consists of a fibrous ring derived from the linea alba and the fusion at this point of the adjacent skin, fasciæ, and peritoneum. The cicatrix is peculiarly different in the two sexes, being shallow and small in the male and deep and wide in the female. In

both sexes at all ages it is stouter in the lower half, owing to the several cords resulting from the obliteration of the hypogastric arteries, the urachus, and the umbilical vein meeting there (Plate 66, Fig. 4). The umbilical vessels have been described in their relation to the fœtal circulation (Vol. I., page 303). The *urachus* is the tubular prolongation of the allantois by which it communicates with the bladder in the fœtus. It should be remembered that in the early stages of development there is a wide gap in the middle line of the abdomen, which gradually closes in by the lateral walls coming together, and that the part last closed is at the umbilicus. *Congenital umbilical hernia* is therefore due to the persistence of the median gap, through which a protrusion of a portion of the intestine into the structures composing the umbilical cord is possible. Such a condition is rare, but whenever the cord appears to be bulky close to the abdomen it should be carefully dealt with. The gradual contraction of the cords representing the obliterated structures drags the umbilicus downward and backward, so that not only does it assume its characteristic puckered depression, but if viewed from the inner side the cords appear to be attached to its lower border, as already described. In consequence of the weaker construction of the upper half of the umbilicus and the normal divergence of the recti muscles in the upper portion of the linea alba, there is less anatomical obstacle to the occurrence of herniæ in this locality. In *infantile umbilical hernia* the protrusion occurs in consequence of the cicatrix resulting from the occlusion of the cord being weak and yielding after birth, so that the intestine may find its way into a pocket above the cords and be merely covered with the peritoneum, subperitoneal fat, extra-peritoneal fascia, and the skin. *Umbilical hernia in the adult* should be more properly designated *median ventral hernia,* as from the nature of the cicatrix it cannot take place exactly at the umbilicus, but must occur through the linea alba above it. Occasionally congenital fistulæ exist at the umbilicus. If urine escapes, it is owing to the urachus not having closed. If fæces are discharged, the cause is the persistence of the vitello-intestinal duct, which connects the rudimentary intestine with the yolk-sac in the fœtus. Such a persistent duct is called the *diverticulum of Meckel,* and it usually arises from the ileum. The position of the umbilicus in the adult

when standing erect will be found to be about opposite the disk between the bodies of the third and fourth lumbar vertebræ, or the tip of the spine of the third lumbar vertebra behind. It varies somewhat in proportion to the obesity or laxity of the abdominal wall. It is always below the centre of the middle line extending from the ensiform cartilage to the pubes. At the age of two years the umbilicus occupies the exact mid-point of the body as measured from head to foot; earlier than this it is below the centre, and in later life it is above it. As it is one of the chief features of reference in this region, it is well to note that in either sex it is situated about two centimetres, or three-quarters of an inch, above a line drawn across the abdomen between the highest points of the crests of the ilia.

The *landmarks of the abdomen,* besides the umbilicus, are the prominences of the skeleton which can be felt through the skin. The ensiform cartilage is deeply placed in the hollow between the cartilages of the seventh ribs. This hollow is always present, and is the so-called "pit of the stomach," or *scrobiculus cordis* of the ancients. The tip of the ensiform cartilage is about on a level with the spine of the tenth dorsal vertebra, and indicates the upper limit of the abdominal cavity. From the ensiform cartilage downward and outward on each side the cartilages of the successive ribs which join the seventh can be easily recognized. In a thin person, during inspiration the digitations of the serratus magnus and external oblique muscles can be seen at the sides over the lower rib. The abdomen is narrowest below the tenth rib, where it is commonly called the waist. The anterior superior spinous processes of the ilia are subcutaneous and easily recognizable. The spinous processes of the pubic bones are also conspicuous in thin persons, but when there is much fat they are hidden, especially in the female, and can be reliably felt only by abducting the thigh of the side in question and thus rendering prominent the tendon of the adductor longus muscle, which is attached immediately below the pubic spine (Plate 87, No. 34).

For the purpose of conveying an accurate impression as to the location of the organs within the abdomen, it has long been the custom to map out carefully the anterior abdominal wall into nine sub-regions

(Plate 97), by drawing two transverse lines, one between the cartilages of the tenth ribs and the other between the superior iliac spines, and bisecting them with two slightly-converging lines drawn from the cartilages of the eighth ribs to the spines of the pubes. The *epigastric region* is in the middle, between the *right* and *left hypochondriac*. The *umbilical region* is below the epigastric, and has the *right* and *left lumbar* on either side of it. Below the umbilical is the *hypogastric region*, with the *right* and *left inguinal* respectively at each side. Owing to the variation in the condition of many of the important viscera, the contents of these different divisions can be only approximately defined. Such relations as may be accepted as reliable and of use for application in diagnosis will be considered with the special anatomy of the abdominal organs.

In this connection, however, it is well to bear in mind that in all examinations of this region the patient should be on his back, with the shoulders slightly elevated, and with the thighs flexed, so that the abdominal wall may be relaxed. In all cases where extreme care is requisite to decide upon any grave question, the bowels and bladder should be evacuated. The anterior wall of the abdomen is freely movable, and the experienced touch can usually detect the outline or character of many of the structures within. The anterior wall varies in thickness in different individuals, principally in the amount of fat in the superficial fascia. This fascia is loose above, with comparatively little fat, and continuous with the superficial fascia of the thorax; below it is firmer, more fatty, and continuous with the same fascia over the thighs. Dissection shows that there are two layers of the superficial fascia, the subcutaneous layer containing the greater proportion of the fat in its areolæ. The amount of fat which accumulates in this region is sometimes enormous. In a woman upon whom the Cæsarean operation was performed by the author, it measured four and one-half inches. The superficial vessels and nerves are generally close to the deep layer of the superficial fascia, so that in incised wounds they often escape injury. The deep layer of the superficial fascia blends with the deeper fascia of the abdomen along the middle line as far as the symphysis pubis, and with the under portion of the reflection of the tendons of the external oblique muscles

in the groins (Poupart's ligaments), where it becomes continuous with the fascia lata.

The areolar tissue over the pubes consists of several additional layers interspersed with coarse fat, and produces an elevation which is provided with hairs and called the *mons pubis.* The fascia is not attached in the interval between the pubic symphysis and spine, but in the male it is destitute of fat, and the two layers combine and are prolonged over the spermatic cord into the scrotum, becoming the dartos. In consequence of this provision, urine, when extravasated, may find its way to the wall of the abdomen, but will be prevented from reaching the thigh by the barrier offered by the attachment of the deep fascia to Poupart's ligament.

The deep layer of the superficial fascia contains elastic fibres, and corresponds to the *tunica abdominalis* of animals. In the middle line at the lower part of the linea alba it sends fibrous prolongations to the dorsum of the penis, forming the suspensory ligament of that organ (Plates 55, 56, 68, and 69). It is of surgical value to note that the deeper layer of the fascia which ensheathes the penis is continuous with the deep fascia of the perineum (Colles's fascia). This is further explained on page 163.

The *superficial arteries of the abdomen* are of small size. They are chiefly derived from the superior epigastric branch of the internal mammary (Vol. I., page 257) and the branches from the superficial epigastric and circumflex iliac, which are branches of the common femoral arteries (Plates 54, 68, and 70). There are numerous *superficial veins over the front of the abdomen,* which are often distinguishable through the skin. They are principally tributaries to the axillary and internal saphenous veins, besides communicating freely with one another and the venæ comites of the deeper arteries. In cases of interference with the passage of the blood through the inferior vena cava, the surface veins become varicosed. In this way a *lateral vein* will sometimes be brought into relief. It joins the axillary and femoral veins, and is of interest as it has been shown to be provided with valves so arranged that the blood in the veins above the umbilicus is directed to the axilla, while below the umbilicus it passes to the groin. Injections, however, can be made to flow one way or the other, so that the valves offer little resistance.

The *lymphatic vessels of the abdominal wall* have generally the direction attributed to the blood in the veins just described. The supra-umbilical lymphatics pass toward the glands of the axilla; the infra-umbilical lymphatics, toward the inguinal glands. The deeper lymphatic vessels probably communicate with the mediastinal glands.

Upon dissecting the fascia from the aponeurosis of the external oblique muscle, two rows of *cutaneous nerves* are readily exposed (Plate 54). They are accompanied by minute perforating arteries, which are derived from the epigastric, lower intercostal, and lumbar arteries. The *anterior cutaneous nerves* emerge on each side from the sheaths of the recti muscles near the lineæ semilunares. Above the umbilicus they are branches of the seventh, eighth, ninth, tenth, and eleventh dorsal or intercostal nerves. The *lateral cutaneous nerves* emerge at the sides and pass parallel one to the other obliquely downward toward the linea alba, following a continuation of the lines of the ribs (Plate 54). These nerves are supplied by the lowest seven pairs of dorsal and upper two pairs of lumbar nerves. It should be observed that they are distributed to both the muscles and the integument of this region, thereby contributing to a very important practical association. The protection which is afforded to the viscera by the ready contraction of the muscles of the abdominal wall in sudden exposures to cold or contusions is due to this peculiar innervation. Furthermore, as the abdominal nerves are prolongations of the nerves which supply the lower intercostal muscles, there is an intimate relation with the movements of respiration. Too exact an impression cannot be had of the origin and course of these nerves, as inferences may be drawn from them which will serve to elucidate many of the complex problems pertaining to this region constantly presented to the physician. To particularize, the seventh and eighth lateral cutaneous nerves issue between the serratus magnus and external oblique muscles, while the ninth, tenth, and eleventh pierce the external oblique muscle (Plate 54), and each divides into a posterior and an anterior branch. The lateral cutaneous branch of the twelfth intercostal or *subcostal* nerve has no posterior branch. It emerges from the oblique muscle below the eleventh rib, and passes behind the anterior spine of the ilium to

supply the skin of the contiguous gluteal region. A lateral cutaneous branch of the first lumbar nerve follows the above nerve in its distribution, being parallel and posterior to it. By attention to this feature of the anatomy of the abdominal wall, many obscure spinal affections may be localized, as is illustrated by the cutaneous symptoms attending Pott's disease, where, as a consequence of pressure upon the nerves at the vertebral foramina, there is a sense of constriction about the abdomen, so that children suffering with this affection often complain of pain in the region of the navel. The position of the caries of the spine may also be determined by a careful study of the symptoms, as the cutaneous pain indicates what particular nerve or nerves are involved. For practical purposes, therefore, it should be remembered that the skin over the epigastrium is supplied by the sixth and seventh intercostal nerves, and that about the umbilicus by the ninth and tenth nerves, and that the groins receive the cutaneous branches from the upper lumbar nerves (the *ilio-hypogastric* and the *ilio-inguinal nerves*, page 79), which are close above Poupart's ligament (Plates 54 and 68, Fig. 1).

The areas of distribution of the sensory nerves of the anterior wall of the abdomen (Plate 97) possess still greater significance, because the spinal nerves from which they originate assist in supplying the abdominal viscera through the communications especially of the lower seven intercostal nerves with the corresponding thoracic sympathetic ganglia, whence are derived the greater and lesser splanchnic nerves (Vol. I., page 320). The lumbar sympathetic cord (page 78), which communicates with the lumbar spinal nerves, although situated within the abdomen (Plate 63, No. 14), more especially relates to the pelvic viscera. The fact that the gangliated sympathetic nerve-cord continues through the abdomen without directly supplying the abdominal organs, which, on the contrary, receive their nerves indirectly from the splanchnic nerves, originating within the thorax, as above described, is to be accounted for only by the evident importance of the interdependence between these regions. There are many diseases which illustrate this nerve-relationship, and it has been especially pointed out that in acute peritonitis the abdominal muscles become contracted and unyielding, while the slightest

pressure is intolerable to the surface, and the inspirations are entirely thoracic, thereby insuring rest to the inflamed structures.

The muscles of the lateral wall of the abdomen are arranged in superposed strata, three on each side, and are named after the direction of their fibres,—the external (or descending) oblique, the internal (or ascending) oblique, and the transversalis. The aponeuroses or tendinous expansions of these muscles are very strong in front, and are peculiarly disposed so as to form sheaths for the recti muscles, which extend on each side of the middle line from the sternum to the pubes. Upon removal of the skin and superficial fascia from the abdominal parietes the *external oblique muscle* is exposed (Plate 54, No. 4). It is the largest of the three layers of muscles, and arises by fleshy slips from the outer surfaces of the lower seven ribs, the last slip being attached to the apex of the twelfth rib. The upper five slips interdigitate with the serratus magnus muscle, and the three lower with the costal origins of the latissimus dorsi muscle. The slip to the ninth rib is usually larger than the slips above and below it, which diminish in successive order. The component fibres of this muscle descend with varying obliquity: the upper ones, becoming tendinous in a curved line extending outward from the eighth rib to the front of the iliac crest, pass forward and interlace with the corresponding fibres of the opposite muscle at the linea alba, while the lower ones pass almost perpendicularly from the lower ribs to the anterior part of the outer lip of the crest of the ilium, where they are inserted. The most posterior fibres of this muscle constitute a free border which enters into the formation of *Petit's triangle* (described in the region of the back, page 177). The tendinous portion of the external oblique muscle is remarkably well developed toward the lower margin of the abdomen in the groin, where great strength is requisite to sustain the pressure of the viscera from within. Here the tendon, consisting mainly of fibres from the origin about the tenth rib, stretches from the anterior superior spine of the ilium to the spine of the pubis, forming a thick border called **Poupart's ligament.**

This structure forms the boundary-line between the abdomen and the thigh, and, as it naturally curves convexly downward over the muscles,

PLATE 54.

The skin and superficial fascia removed from the anterior surface of the abdomen upon the right side to show the external oblique muscle and the formation of Poupart's ligament, and the external portion of the sheath of the rectus muscle removed on the left side, showing the rectus and internal oblique muscles; also the superficial dissection of the supra-pubic and inguinal regions.

1. A branch of a lateral cutaneous nerve.
2. The right linea semilunaris.
3. One of the anterior cutaneous nerves and arteries.
4. The right external oblique muscle.
5. The umbilicus.
6. The cut skin and superficial fascia.
7. One of the anterior cutaneous nerves and arteries.
8. Poupart's ligament.
9. The right superficial epigastric artery.
10. The right superficial circumflex iliac artery.
11. The right superficial pubic artery.
12. The intercolumnar fascia.
13. The upper margin of the superficial abdominal opening.
14. The external spermatic or intercolumnar fascia.
15. The inner pillar of the superficial abdominal opening.
16. The outer pillar of the superficial abdominal opening.
17. The right spermatic cord.
18. The right ilio-inguinal nerve.
19. The suspensory ligament of the penis.
20. The left superior linea transversa, opposite the cartilage of the seventh rib.
21. The left middle linea transversa, opposite the cartilage of the tenth rib.
22. The expansion of the aponeurosis of the left internal oblique muscle at the outer border of the rectus, forming the left linea semilunaris.
23. The left inferior linea transversa, opposite the umbilicus.
24. The left internal oblique muscle.
25. The cut branch of the left twelfth intercostal nerve.
26. The position of the left deep abdominal opening.
27. The left ilio-hypogastric nerve.
28. The left ilio-inguinal nerve.
29. The left pyramidalis muscle.
30. The looped fibres of the left cremaster muscle.
31. The left fascia lata.

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...ssected, Photographed and Colored from Nature by George McClellan, M.D.

vessels, and nerves which pass from one region to the other, it is also known as the *inguinal* or *femoral arch.* The curved direction of Poupart's ligament should be understood to be due to the attachment of the fascia lata to its lower border. When this fascia is separated, as in a dried specimen, a very erroneous impression of the direction of Poupart's ligament is obtained, for it then appears to take a straight course from the iliac spine to the pubes.

Immediately above Poupart's ligament the aponeurosis of the external oblique muscle as it approaches the pubes separates, in order to give exit to the spermatic cord in the male or to the round ligament of the uterus in the female, while the upper fibres pass to the symphysis of the pubes, where they interlace with the fibres of the fellow-muscle from the opposite side. The space thus formed, for the spermatic cord or the round ligament, is called the **superficial abdominal opening,** or ring (Plate 54, No. 13, and Plate 68, Fig. 2, No. 15). It can be recognized in the living male by invaginating the loose tissues over it so as to pass the finger beneath the subcutaneous fat, and in the female by feeling for the insertion of the tendon of the adductor longus muscle while the thigh is abducted (page 83). The spermatic cord or the round ligament occupies the so-called *inguinal canal,* which is rather a tract of tissue formed congenitally and capable of being distended or ruptured in the various forms of hernia which occur in this locality (page 87).

When the under surface of Poupart's ligament is examined, it appears to have its lower edge turned inward in a narrow shelf-like manner, and from this inward projection the subjacent internal oblique muscle partially arises. The tendinous insertion at the pubic spine is prolonged outward in a triangular expansion for about two centimetres, or three-quarters of an inch, along the ilio-pectineal line. This is *Gimbernat's ligament,* the concave outer border of which is directed toward the femoral vessels (Plate 76, Fig. 2, No. 1).

The *superficial abdominal opening,* which is formed as above described, is very oblique, and the margins have been named its pillars or columns, the *outer pillar* being formed by Poupart's ligament, which is attached

to the pubic spine, the *inner pillar* by the band of fibres which is inserted at the pubic crest. The inner is much the weaker of the two. If the dissection of the superficial fascia over the inguinal region is carefully made, some *arciform fibres* of condensed connective tissue will be found extending across the tendon of the external oblique muscle. Some of these are attached to the pillars of the superficial opening, and hence are called the *intercolumnar fascia* (Plate 54, No. 14). An expansion from this delicate tissue can be traced over the spermatic cord into the scrotum, constituting the *external spermatic fascia.* The superficial opening measures, in the male, three centimetres, or an inch and a quarter, in length; in the female it is about half this size.

Before detaching the external oblique muscles the *linea alba* should be examined. It is here that the median fusion of the tendons of all the muscles takes place above and below the umbilicus. As it is crossed by few vessels, it is usually selected as the surgical *line of safety* for incision in most of the operations upon the abdominal cavity. The linea alba is always wider above the umbilicus than it is below it, where the two recti muscles approach each other very closely. Very often there are spaces between the fibres of the linea alba through which fatty nodules from the subperitoneal tissue may protrude.

The *internal oblique muscle* (Plate 54, No. 24) is thinner than the external. It arises by fleshy fibres from the outer half of the inner surface of Poupart's ligament (page 9), from the middle lip of the crest of the ilium, and from the lumbar fascia above the superior gluteal line. From these origins the fibres radiate as follows: those from the lumbar fascia pass upward to the two lowest ribs; the contiguous posterior iliac fibres, the thickest portion, diverge to be inserted into the lower borders of the cartilages of the tenth, ninth, eighth, and seventh ribs; and the middle iliac fibres pass forward to the border of the rectus muscle, where they become tendinous and form the *linea semilunaris.* Along the upper three-fourths of each linea semilunaris they divide into two layers, the anterior of which passes in front and the posterior behind the rectus muscle, thus constituting its proper sheath. The two layers unite at the linea alba and blend with its other constituent fibres. The fibres from the anterior

portion of the iliac origin unite with those arising from Poupart's ligament, and, becoming tendinous, arch forward and downward. At the lower fourth of the linea semilunaris, instead of splitting as they do above, they continue in one firm sheet in front of the rectus to the linea alba. The most anterior of the fibres from Poupart's ligament are inseparable from the underlying part of the transversalis muscle, and are inserted into the crest of the pubic bone, forming the *conjoined tendon* (Plate 68, Fig. 4, No. 9).

The spermatic cord as it rests upon the outer pillar of the superficial opening is covered with a fascia which is derived from the contiguous border of the internal oblique muscle,—probably at the time of the descent of the testicle. This fascia consists of alternating loops of loose cellular tissue and muscle-fibres, called the *cremaster*, which are disposed over the front of the spermatic cord, and, becoming associated with the external spermatic fascia (page 85), so that the lower fibres are spread over the tunica vaginalis testis, they are called the *tunica cremasterica.* The cremaster muscle is supplied with a special artery (the *cremasteric*) (Plate 68, Fig. 2, No. 14) from the epigastric, and a nerve from the genital branch of the genito-crural nerve (Plate 68, Fig. 3, No. 7). The cremaster muscle is absent in the female. The ilio-hypogastric and ilio-inguinal nerves pierce the internal oblique muscle, and will be seen in the dissection passing along the upper border of Poupart's ligament (Plate 68, Fig. 3, No. 3). In order to detach the internal oblique muscle without interfering with the underlying transversalis muscle, it should be divided just above the crest of the ilium, where the *deep circumflex iliac artery* will be found running upward and outward in the connective tissue over the transversalis muscle. Upon the surface of this muscle are the anterior continuations of the seventh, eighth, ninth, tenth, eleventh, and twelfth intercostal nerves and the ilio-hypogastric and ilio-inguinal nerves, with their accompanying vessels (Plate 55).

The *transversalis muscle* arises by six fleshy slips from the inner surfaces of the six lower costal cartilages, interdigitating with the diaphragm by a tendinous expansion from the lumbar fascia in the back and by fleshy and tendinous fibres from the anterior portion of the inner

lip of the crest of the ilium. The latter are sometimes augmented by some fibres from the adjacent part of Poupart's ligament. The direction of the bulk of these fibres is transversely across the abdomen. Before they reach the semilunar line they become tendinous, and at the upper two-thirds of the rectus muscle they blend with the posterior layer of the internal oblique, to be inserted with it at the under surface of the linea alba. At the lower third the fibres of the aponeurosis of the transversalis pass in front of the rectus, with the whole of the corresponding part of the tendon of the internal oblique (page 13). Its lowest border is inseparable from the internal oblique, with which it forms the *conjoined tendon* and is inserted into the pubic crest (Plate 68, Fig. 4, No. 9). There is a small band of the tendon of the transversalis which is reflected downward and outward from the conjoined tendon and passes behind the spermatic cord. This is known as the *reflected tendon of Cooper.*

The *recti muscles,* which are ensheathed by the expansions of the tendons of the lateral abdominal muscles already described, are situated in front of the abdomen, and separated from each other by the linea alba. In order to expose either of them, the sheath must be slit up and removed (Plate 54), when the muscle will be found to arise chiefly from the crest of the pubes by a tendon which is sometimes augmented by a band of fibres from the symphysis. Each muscle broadens as it ascends, is crossed by the tendinous intersections, which are called the *lineæ transversæ,* and is attached by three fleshy slips to the outer surfaces of the cartilages of the fifth, sixth, and seventh ribs. The lineæ transversæ are usually three in number,—one being on a line with the umbilicus, one opposite the ensiform cartilage, and one intermediate (Plate 54). Occasionally there is also a tendinous intersection below the umbilicus, but it is never so well marked as the others. These intersections are considered to be incomplete repetitions of the ribs in the abdominal wall, and analogous to the bony abdominal ribs found in some of the lower animals. If one of the lineæ transversæ is examined carefully, it will be noticed that upon the under surface there are some muscular fibres which pass from one of the fleshy portions to another, and that the sheath of the muscle is not so closely

adherent behind to the lineæ transversæ as it is in front. Some of the fibres of the pectoralis major muscle take origin from the upper part of the sheath of the rectus where it overlies the ribs. The lower fourth of the rectus muscle rests solely upon the extra-peritoneal fascia, in consequence of the entire tendons of the transversalis and internal oblique muscles passing in front in this locality, and the termination of the under portion of the sheath of the rectus presents occasionally a crescentic border, known as the *plica semilunaris*, or *fold of Douglas* (Plate 74, Fig. 1, No. 18). This fold is not always well marked, because in some cases the transversalis continues to send its fibres behind the rectus. The deep epigastric and superior epigastric arteries respectively ascend and descend within the posterior portion of the sheath of the rectus muscle (Plate 55, No. 21). The deep epigastric artery (page 75) enters the sheath at the border of the semilunar fold.

The *pyramidalis muscle* arises from the pubic crest in front of and superficial to the origin of the rectus muscle (Plate 54, No. 29). It is often unilateral, and in some individuals is entirely wanting or irregularly developed on the two sides. This little muscle is provided with a distinct sheath, which contributes in the male to the formation of the *triangular fascia* by sending an expansion downward to blend with the pubic attachment of Poupart's ligament.

The *functions of the abdominal muscles* may be in a measure inferred from the direction of their fibres, which, because of their crossed arrangement at the sides, serves to strengthen the abdominal wall. When all the muscles act together, they compress and support the viscera and protect them from external injury; and, the pelvis and the thorax being fixed, they variously assist in the expulsion of the contents of the stomach in vomiting, of the urine from the bladder, of the fæces from the rectum, and of the fœtus from the uterus in parturition. In most of these efforts they are aided by the descent of the lateral leaflets of the diaphragm (Vol. I., page 320). The muscles of the abdomen are quiescent and relaxed during inspiration, but they aid in expiration when the spine is fixed, by drawing the lower ribs downward and inward. When the pelvis is fixed, the thorax is inclined forward by the muscles

of both sides acting together: if the muscles of one side act, the trunk is bent to that side. The oblique muscles cause rotation of the trunk, the external oblique turning the face to the opposite side and the internal oblique turning it to the same side. This is seen in mowing, where the right external oblique and the left internal oblique are simultaneously brought into action. In climbing, the thorax serving as the base of attachment, the abdominal muscles draw the pelvis upward and forward. The chief action of the recti muscles is concerned in raising the body from the recumbent position. Their peculiar segmentation and enclosure in so firm a sheath enable them to maintain their action in all possible bendings of the body. The pyramidalis assists the lower part of the rectus, and serves to make tense the linea alba.

The *extra-peritoneal fascia* (Plate 55, No. 20) is exposed upon removal of the transversalis muscle, with the fleshy portion of which it is so intimately associated that it has commonly been called the transversalis fascia. This name is misleading, and should be discarded, as the fascia is a distinct membrane. It is very delicate in the upper part of the abdomen, where it is continuous with the infra-diaphragmatic fascia. It gradually becomes thicker and stronger below, especially in the neighborhood of Poupart's ligament, to which it is attached. It fills up the interspace between the lower margin of the transversalis muscle and Poupart's ligament, and is pierced by the spermatic cord about two centimetres, or a finger-breadth, above the middle of Poupart's ligament. This point corresponds to the position of the **deep abdominal opening**, or ring, although the latter does not naturally appear until the tissue which is prolonged about the structures of the cord is separated. This tissue is an expansion from the extra-peritoneal fascia, and because of its funnel shape it is called the *infundibuliform fascia*, or *internal spermatic fascia* (Plate 69, Fig. 1, No. 5). It forms one of the coverings of an oblique inguinal hernia (page 86). On the inner side of the spermatic cord the extra-peritoneal fascia blends with the conjoined tendon as well as with the tendon of the rectus muscle. The *deep abdominal opening* should be understood to be artificial, but, as it forms the commencement of the **inguinal canal**, or **inguinal tract**, which

lodges the spermatic cord in the male or the round ligament in the female, its position is of great importance. In the adult the *inguinal tract* is an oblique passage from four to five centimetres, or from one and a half to two inches, in length, extending between the deep and the superficial opening. The deep epigastric artery can be felt through the extra-peritoneal fascia ascending behind the spermatic cord, close to the internal border of the deep abdominal opening (Plate 69, Fig. 1, No. 3). The further relations of the parts concerned in the anatomy of hernia in the inguinal region are so important that they are considered under a special heading (page 81). The extra-peritoneal fascia is prolonged in front of the femoral vessels behind Poupart's ligament, and merges with the proper sheath of the vessels. It is attached to the pubes behind the conjoined tendons on each side, and descends into the pelvis. Beneath the extra-peritoneal fascia, extending across the lower part of the wall of the abdomen, is the *subperitoneal areolar tissue*, consisting of loose connective tissue containing more or less fat in its meshes. This tissue is especially pronounced in the neighborhood of the deep abdominal opening, where it is called the *fascia propria of Cooper*.

By careful dissection, the extra-peritoneal fascia and subperitoneal tissue can be removed so as to expose the outer surface of the *parietal peritoneum*, which is the delicate endothelial layer lining the anterior wall of the abdomen (Plate 56, No. 4). Its outer surface presents several whitish cords converging toward the umbilicus. The cord which descends obliquely from the fissure between the right and left lobes of the liver and is enveloped in a special fold of the extra-peritoneal fascia (*Richet's fascia*) represents the obliterated umbilical vein. It is also included in a fold of the peritoneum which constitutes the *falciform ligament* of the liver. The three cords which ascend to the umbilicus from the fundus of the bladder are respectively on either side the remains of the right and left hypogastric arteries, and the urachus in the centre (Plate 56, Nos. 6, 7, and 14). When the under surface of the parietal peritoneum is examined, after opening the peritoneal space or cavity, it will be noticed that the peritoneum bulges slightly forward on each side into the triangular spaces between the urachus and the hypo-

PLATE 55.

The external and internal oblique muscles of the abdomen removed on the right side to show the transversalis muscle, and all the abdominal muscles removed on the left side to show the extra-peritoneal fascia; also the anastomoses of the deep epigastric and internal mammary arteries, the internal or deep abdominal opening, etc.

1. The superior epigastric branch of the right internal mammary artery.
2. The cartilage of the right seventh rib.
3. The cartilage of the right eighth rib.
4. Branches of the right ninth intercostal nerve and artery.
5. Branches of the right tenth intercostal nerve and artery.
6. The right transversalis muscle.
7. Branches of the right eleventh intercostal nerve and artery.
8. The umbilicus.
9. Branches of the right twelfth intercostal nerve and artery.
10. The right deep circumflex iliac artery.
11. The right ilio-hypogastric nerve.
12. The right ilio-inguinal nerve.
13. The right deep epigastric artery and its venæ comites (separated).
14. The position of the right deep abdominal opening.
15. The lower border of the transversalis muscle arching to join the insertion of the internal oblique muscle.
16. The infundibuliform fascia, enveloping the right spermatic cord.
17. The suspensory ligament of the penis.
18. The right cremaster muscle.
19. The superior epigastric branch of the left internal mammary artery.
20. The extra-peritoneal fascia, carefully dissected from the posterior surfaces of the aponeuroses of the rectus and transversalis muscles on the left side.
21. The anastomosis of the left deep epigastric and superior epigastric arteries.
22. The left superficial circumflex iliac artery.
23. The left deep epigastric artery with its venæ comites.
24. The infundibuliform fascia expanded from the extra-peritoneal fascia around the left spermatic cord.
25. Supra-pubic layer of areolar and adipose tissue.

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gastric cords, forming the *inner inguinal pouches*, which are immediately behind the superficial abdominal openings. A hernial protrusion through one of these spaces is known as a *direct inguinal hernia*. The epigastric arteries pass upward to the folds of Douglas (page 15), parallel and external to the hypogastric cords. They form the outer boundaries of the *triangular spaces of Hesselbach*, which have the tendon of the corresponding rectus muscle on the inner side and Poupart's ligament below. Just external to the epigastric artery and above Poupart's ligament on each side there is a triangular bulging of the peritoneum, which corresponds to the deep abdominal opening and forms the *outer inguinal pouch*. A hernia occurring here is very common, as it follows the course of the testicle. It is known as *indirect inguinal hernia*. Careful examination of the inside of the peritoneum in this locality will reveal the *inferior digital fossa*, which is below Poupart's ligament and internal to the femoral vein. It corresponds to the upper opening of the femoral canal (page 97). The *superior digital fossa* is at the deep opening in the bottom of the outer inguinal pouch, but it is very indistinct. The urachus, hypogastric cords, and often the epigastric arteries are enveloped with special folds (*plicæ*) of the peritoneum derived from the parietal layer (Plate 74, Fig. 2, No. 17).

The cavity of the abdomen extends from the under surface of the diaphragm to the rim of the true pelvis. It is bounded anteriorly and laterally by the parietes, consisting of the muscles, fasciæ, and integument, all of which have been described, and posteriorly by the lumbar vertebræ and muscles (page 215). It is limited above by the cartilages of the false ribs, and below by the crests of the ilia and pubes. It should be remembered that the pelvis is really the lowest part of the abdomen, and that the separation of their respective cavities is entirely arbitrary.

Before proceeding to the particular study of the contents of the abdomen, it is well to take a general view of the parts as they appear upon removal of the anterior wall, so that a proper idea may be obtained of their relations and connections *in situ*. When the body is placed on its back in the horizontal position, the parts, as they normally appear

upon consecutive dissections of this region (Plates 57, 58, 59, 60, 61, 62, and 63), will be found as follows. Beneath the cartilages of the ribs on the right side the *thin anterior border of the liver* is seen, with the *fundus of the gall-bladder* projecting in proximity to the ninth costal cartilage. On the left side, beneath the cartilages of the ribs, in contact with the diaphragm and overlapped by the left lobe of the liver, is the *stomach,* from the greater curvature of which hangs, like a wide, loose curtain, the *great omentum,* consisting of a double layer of the peritoneum, containing fat and blood-vessels (Plate 29, Vol. I., and Plates 56 and 57), concealing all the underlying parts, except, generally, a few convolutions of the small intestine (*jejunum*) in the left iliac fossa. Upon drawing the liver upward and outward, a fold of the peritoneum is exposed, extending from its lower surface to the lesser curvature of the stomach. This is the *lesser omentum.* If the finger is passed over the lesser omentum to the right, between the gall-bladder and the pyloric extremity of the stomach, it will find its way through an opening directed to the left. This is the *foramen of Winslow* (page 29). It has the liver above it and the duodenum below it. It leads into the *lesser cavity* or *bag of the peritoneum* (page 33).

When the great omentum is raised and reflected over the ribs, as in Plate 58, a sacculated portion of the large intestine is seen to cross in its deep surface from right to left. This is the *transverse arch of the colon.* If the latter is traced to the right, it will be found to pass upward under the liver and then turn abruptly downward, forming the *hepatic flexure of the colon.* Thence it can be followed into the right iliac fossa, where it appears dilated and is known as the *cæcum.* As this is the commencement of the large intestine, the old name *caput cæcum coli* should be retained. The hepatic flexure of the colon is commonly found after death to be stained with bile, owing to its intimate relation with the gall-bladder.

In this view (Plate 58) will also be found the loops of the *jejunum* and *ileum,* which are the lower portions of the small intestine. The division into jejunum and ileum is arbitrary, as they are indistinguishable. They appear gathered into *convolutions* covering over the remain-

ing portions of the intestinal tube, the jejunum occupying principally the left lumbar and iliac regions, and the ileum the right lumbar and iliac regions. On drawing the small intestines outward to the left they will be seen to be attached to the spine by a plaited fold of the peritoneum, the *mesentery* (page 35). Within the mesentery the branches of the **superior mesenteric vessels** ramify to their distribution. They can be clearly demonstrated by removing the outer layer of the mesentery (Plate 59). The main artery curves, generally, convexly to the left, and gives off numerous *iliac* and *jejunal branches* to the small intestine. These branches soon bifurcate, their subdivisions inosculating and forming *arches*, from which the terminal arteries arise. The latter are called the *vasa intestini tenuis.* They also subdivide, and, sending their branches in front of and back of the bowel, establish a uniform blood-supply. From the right side of the superior mesenteric artery arise the chief branches which supply the colon. The first is the *inferior pancreatico-duodenalis artery.* This is brought into view in a later dissection (Plate 61, No. 11). The *colica media artery* (Plate 59, No. 4) passes to the transverse colon. The *colica dextra artery* (Plate 59, No. 6, and Plate 60, No. 7) arises below the media and passes to the right lumbar region, where it divides into ascending and descending branches. The last branch of the superior mesenteric artery is called the *ileo-colic artery* (Plate 59). It is the outermost of the iliac arteries, and, passing to the cæcum, also supplies the vermiform appendix.

The ileum and jejunum must be removed to show the branches of the **inferior mesenteric artery** (Plate 60). The trunk of this vessel arises three centimetres, or an inch and a quarter, above the bifurcation of the abdominal aorta into the common iliac arteries. Its branches are the *colica sinistra artery* (Plate 60, No. 30), which supplies the descending colon; the *sigmoid artery* (Plate 60, No. 33), to the sigmoid flexure of the colon; and the *superior rectal* or *hæmorrhoidal artery* (Plate 60, No. 31), which descends to supply the upper portion of the rectum. All the branches of the mesenteric arteries establish free intercommunication, so that there is an uninterrupted supply of blood to all parts of the intestinal tube, so necessary for its physiological function. After the

detachment of the great omentum (Plate 60), the transverse colon can be examined in relation to the spleen in the left hypochondriac region, where it makes another bend, the *splenic flexure,* and passes downward into the left iliac fossa. Here it is peculiarly arranged in a tortuous fold of the mesentery before it terminates in the rectum, and is called the *sigmoid flexure* (Plate 61, No. 33). The sigmoid flexure usually consists of a large loop puckered up into folds, and occupies rather the pelvis than the iliac fossa. In the child, the sigmoid flexure of the colon will often be found extending over into the right iliac fossa before turning into the pelvis (Plate 67, Fig. 2). The sigmoid flexure of the colon is predisposed to *volvulus,* or obstruction by twist, owing to the mesocolon forming a narrow pedicle which may become rotated upon its axis in distention of the bowel.

When the great omentum is removed, the **relations of the stomach** can be examined. The *great cul-de-sac,* or *fundus,* is under cover of the cartilages of the ribs in the left hypochondriac region, in contact with the diaphragm, and reaches as high as the left sixth sterno-chondral joint, a little above and behind the apex of the heart. The *cardiac* or *œsophageal orifice* is always comparatively fixed, and corresponds, in the living, to a point over the left seventh costal cartilage three centimetres, or one and a quarter inches, from its junction with the sternum (Plate 27, Vol. I.). It should be remembered that the shape and size of the stomach are influenced by the pressure of the surrounding organs and by the degree of its distention. (Compare Plate 29, Vol. I., and Plate 57.) In the former the stomach was partially filled with food, in the latter it was flaccid and empty.

The *pyloric* or *intestinal orifice,* which is overlapped by the left lobe of the liver to a greater or less degree, is variable in its position according to the amount of gastric distention, and cannot be indicated except with latitude. When the organ is empty the pyloric orifice is believed to correspond in the healthy adult to a point about five centimetres, or two inches, below the junction of the right seventh costal cartilage with the sternum. Posteriorly the cardiac orifice is about on a level with the spinous process of the ninth dorsal vertebra, and the pyloric orifice with

that of the twelfth (Plate 82). When the pyloric end of the stomach is affected with cancerous disease it is often dragged down by its weight to a point below and to the right of the umbilicus. The operation of *resection of the pylorus* requires a transverse incision just above the umbilicus.

A very small portion of the anterior surface of the stomach is ordinarily in contact with the abdominal wall below and to the left of the ensiform cartilage. When empty the stomach is some distance from the anterior wall of the abdomen, but when distended it is brought forward by the upward rotation of the greater curvature, which is limited by the degree of fixity of the lesser curvature. If there is much flatulence, so that the stomach is excessively distended, the surface-depression below the ensiform cartilage will be obliterated, the transverse colon and the small intestine will be crowded downward below the umbilicus, and the liver will be pushed upward against the diaphragm so as to diminish the moving-space of the heart within the pericardium (Vol. I., page 309). In the operations of *gastrotomy* and *gastrostomy* the stomach is usually found to be very small and hidden under cover of the left lobe of the liver and the costal cartilages, so that the transverse colon occupies its normal position. The latter will be recognized by the *appendices epiploicæ* (page 44).

The posterior surface of the stomach rests upon the spleen, the pancreas, the left kidney, the gastro-splenic omentum, and the transverse mesocolon. When both of the latter peritoneal folds are removed and the stomach is reflected outward upon the thorax, the posterior surface is thus brought into view, as well as the subjacent organs (Plate 61). In this position, of course, the greater and lesser curvatures of the stomach are reversed. The greater curvature is convex, and the lesser curvature is concave. Along the concave border the *gastric artery* (Plate 61, No. 20) anastomoses with the *superior pyloric branch of the hepatic artery* (Plate 61, No. 5), thus forming the *coronaria ventriculi.* The branches of the pneumogastric nerves also enter the wall of the stomach upon the concave border (Plate 36, Vol. I.) near the œsophageal orifice, so that, in the recumbent position, if undigested food is present the fila-

ments of these nerves are liable to be irritated and give rise to many of the distressing symptoms of indigestion. The stomach occasionally presents variations in form, which are probably due to modifications arising from the natural enlargements toward the pyloric extremity. Of these, the bulge on the convex border in this locality is called the *lesser cul-de-sac*, and the dilatation on the concave border is the *pyloric antrum.* In the new-born child the fundus of the stomach is comparatively less pronounced, the whole organ presenting generally the appearance of a curved tube with which the duodenum is directly continuous (Plate 66, Fig. 2). It gradually assumes the characteristic shape and normal position as the child grows older (Plate 67, Figs. 2 and 3). In several dissections the author has observed the stomach occupying an oblique direction with the pyloric extremity toward the right iliac fossa; and in one instance, an adult over forty, the organ was nearly *vertical,* which is its ordinary position in the fœtus at the end of the first month. The stomach is most exposed to injury when it is distended with food, and a wound of this organ at such a time is generally fatal, in consequence of peritonitis caused by the escape of the contents into the cavity of the peritoneum.

The minute anatomy of the stomach is described on page 38.

The duodenum is the first portion of the small intestine, which in the process of development is pressed against the back of the abdominal wall and held in position by a special reflection of the peritoneum. It begins at the pylorus, and forms a horseshoe-shaped curve, with the concavity directed to the left, into which is received the head of the pancreas (Plate 61). It consists of three portions, the first, or *ascending,* the second, or *descending,* and the third, or *transverse,* the latter terminating opposite the left side of the second lumbar vertebra, where the duodenum turns forward into the jejunum. The *first portion of the duodenum* can be seen only by raising the liver and drawing the stomach to the left. It lies in direct relation to the gall-bladder and caudate lobe of the liver, and turns downward opposite the neck of the gall-bladder. Here it is close to the hepatic artery, the vena portæ, the hepatic duct, and the *gastro-duodenalis artery* (Plate 61, No. 6). It is separated from these structures by the foramen of Winslow (page 29).

The first portion of the duodenum is the most movable part, as it is held in place chiefly by its attachment to the head of the pancreas. The *second portion of the duodenum* rests upon the right kidney and supra-renal capsule, and on the inferior vena cava, which intervenes between it and the right psoas muscle. This portion of the duodenum usually descends lower in the male than in the female, reaching in the former the disk between the third and fourth lumbar vertebræ and in the latter the middle of the third lumbar vertebra. The *ductus communis choledochus* opens into the lower angle of the duodenum, formed by the descending and transverse portions (Plate 65, Fig. 2, No. 15). The *third portion of the duodenum* is directed somewhat obliquely upward across the spine, passing over the right psoas muscle, the inferior vena cava, the right crus of the diaphragm, and the aorta. Both the descending and transverse portions of the duodenum are only partially covered with the peritoneum, and they are the most fixed portions of the small intestine. The termination of the duodenum is held firmly in place by a special band of fibrous tissue which descends from the left crus of the diaphragm. Its termination presents two peculiar *flexures*, the first being upward on the left of the superior mesenteric artery and the second forward into the jejunum. Its termination is in front of the left crus of the diaphragm and the left renal vessels. When the duodenum is undisturbed in the dissection of this region, the superior mesenteric artery and superior mesenteric vein pass over it from beneath the pancreas (Plate 61, Nos. 28 and 29). The entire duodenum measures about twelve finger-breadths (hence its name), or twenty-two centimetres, in length.

After the jejunum and the ileum and the special folds of the mesentery belonging to them are removed, the cæcum and the vermiform appendix are brought into view (Plate 61, Nos. 14 and 15). In the adult the **cæcum** is situated in the right iliac fossa, about two and a half centimetres, or an inch, from the anterior superior spine of the ilium toward the middle line of the abdomen. It is provided with a special investment of the peritoneum, which is often invaginated behind it into a *subcæcal pouch*. At birth the cæcum is imperfectly developed, and

PLATE 56.

The transversalis muscle and the extra-peritoneal fascia carefully removed to show the parietal peritoneum on the right side of the abdomen and a portion of the great omentum on the left.

1. The cartilage of the right sixth rib.
2. The cartilage of the right seventh rib.
3. The cartilage of the right eighth rib.
4. The parietal peritoneum.
5. The anterior superior spine of the right ilium.
6. Fold of the peritoneum corresponding to the obliterated right hypogastric artery.
7. The obliterated urachus.
8. The anterior surface of the distended bladder, uncovered by the peritoneum.
9. The right spermatic cord.
10. The suspensory ligament of the penis.
11. The anterior surface of the stomach, covered by the peritoneum.
12. The great omentum.
13. Portion of a coil of the jejunum.
14. Fold of the peritoneum corresponding to the obliterated left hypogastric artery.
15. The left superficial circumflex iliac artery.
16. The left fascia lata.
17. The left spermatic cord.

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Armstrong & [illegible] Boston

appears (Plate 66, Fig. 4, No. 4) as a long coiled portion of the bowel extending across the abdomen below the transverse colon. The cæcum is usually entirely surrounded with the peritoneum, and is therefore readily displaced in the various positions which the body may assume during life. The ascending colon passes upward in the adult from the cæcum to the under surface of the liver (page 20). This portion of the colon where it joins the cæcum is generally in contact with the back wall of the abdominal cavity in the loin (Plate 84, Fig. 2, No. 21). It is covered with peritoneum only in front and at the sides. There is often a great deal of loose areolar tissue between the posterior surface of the cæcum and the iliac fascia, which is the seat of abscess in cases of perforation of the cæcum or of the appendix.

The vermiform appendix, or **vermiform process,** is very variable. It is usually from seven to fifteen centimetres, or from three to six inches, in length, and from five to six millimetres, or about a quarter of an inch, in diameter. It arises from the lower and posterior part of the cæcum, and terminates in a free rounded blunt end. It has a small mesentery of its own, which ties it more or less loosely to the back surface of the cæcum. It is usually directed upward in a flexuous course toward the termination of the duodenum (Plate 61, No. 14), but it will be found not uncommonly hanging downward into the right iliac fossa between the cæcum and the ileum (Plate 69, Fig. 4, No. 2). In every case, within the author's observation, where this process has been involved in *perityphlitis* in consequence of the lodgement of an intestinal concretion or a foreign body, and an operation was required for its relief, the position within the iliac fossa was noticed. The vermiform appendix is the rudiment of the elongated cæcum of the herbivorous animals, in which this portion of the intestinal canal serves as a reservoir for the elaboration and absorption of food. The cæcum in man has therefore been said to offer an anatomical protest against a purely vegetable diet. The ileo-cæcal region is frequently the seat of obstruction from foreign bodies, owing to the presence of the *ileo-cæcal valve* (page 45), which guards the entrance of the ileum into the cæcum (Plate 65, Figs. 4 and 5).

When the stomach is raised from under the ribs, the spleen and the

pancreas are brought into view (Plate 61). The *spleen* is the deep-purplish-colored organ situated under cover of the cartilages of the ninth, tenth, and eleventh ribs. It presents various notches in the anterior border, which are sometimes palpable through the abdominal wall when the spleen is enlarged. The *pancreas* is the pinkish-gray-colored glandular body which lies behind the stomach, extending from the concavity of the duodenum on the right to the hilum of the spleen on the left. It is situated directly over the first lumbar vertebra, between the cœliac axis above and the superior mesenteric artery and superior mesenteric vein below (Plate 61, No. 26).

The anatomy of the spleen is described on page 59; that of the pancreas, on page 57.

After having obtained an accurate idea of the normal positions of the abdominal viscera, and before removing them from the body to study the peculiarities of their structure, it is well to examine carefully the complicated reflections of the serous membrane,—called the **peritoneum**,—which holds many important relations to most of the organs, not only from a physiological point of view, but also with regard to the interpretation of many diseases with which they may become involved, and the surgical procedures practised for their relief. It should be first understood that the various folds of the peritoneum which pass from the abdominal wall to the viscera are designated according to their attachments,—viz., *mesentery*, *mesocolon*, *mesorectum*, etc. Folds from the abdominal wall to solid organs are called *ligaments*. Where the folds which pass from one viscus to another are double, they are called *omenta*.

In order to comprehend the complexity of the arrangement of the peritoneum as it ordinarily appears in the adult, it is essential that some knowledge should be possessed of the early stages of embryonic development in which the abdominal viscera are differentiated.

Any one who has not given this subject thought would probably be astounded by the statement that the liver and the pancreas are outgrowths of the duodenum; but it is a fact upon which depends the explanation of much that belongs to this difficult study.

When the alimentary canal first assumes the tubular form it is a

simple straight cylinder placed in front of the vertebral column, attached to it and to the rest of the embryo by a membranous fold or rudimentary mesentery. By degrees the intestine, growing in length, becomes looped at the centre and straight at its upper and lower ends, whilst the portion which is destined to become the stomach is dilated. The liver is developed from the duodenum in the lower surface of the primitive diaphragm, and contains the ducts of Cuvier, or great venous trunks passing to the right auricle of the heart. Owing to these connections the duodenum becomes fixed very early, and on this account the stomach, as it enlarges, is caused to rotate around its vertical axis, its convex or vertebral border being turned forward, while its concave or abdominal border is turned backward. In this process of development the stomach, which was at first placed vertically, becomes drawn gradually obliquely to the right, and then transversely. In these evolutions it naturally carries with it the membranous fold from which the omenta are afterward produced. The vertical position of the stomach may continue in adult life, as already stated (page 24), and it probably does so more frequently than has been observed, but the author is convinced from many dissections and autopsies that its normal position after birth is as seen in Plate 66, Fig. 2. It is thought that the peculiar shape of the fundus of the organ is due to the action of the layers of muscular fibres in its wall upon the food, and in newly-born children the fundus does not exist. The curvatures of the stomach follow as a sequence upon its dilatation and change of position, and the mesial fold of the peritoneum surrounding it becomes the sac of the omentum, the portion covering the right side of the stomach being turned inward and the portion over the left side passing over the front wall of the stomach, so that its free edge becomes the anterior boundary of the omental *foramen of Winslow,* the opening between the greater and lesser involutions or cavities of the peritoneum, as they are called. These involutions are partly due to the unequal constriction of the pyloric and œsophageal ends of the stomach. The foramen of Winslow is occasioned by the serous membrane which originally was on the right side of the stomach becoming turned behind it and compressed by the duodenum in its fixed position

and relation to the liver, as above described. In the early embryo there is no distinction between the upper and the lower part of the intestine until the formation of the cæcum, which is at first about the centre of the canal, and is a simple tubular diverticulum which later dwindles at its free part, becoming the vermiform appendix (page 27). After the appearance of the cæcum the primitive intestinal canal undergoes great changes: the lower portion increases in calibre, and the upper elongates rapidly and becomes looped. The loops of the upper or small intestine are peculiar because the tube as it elongates twists on itself below the stomach, so that the lower part passes in front of the upper and consequently draws the peritoneum from its abdominal surface. The looped crossing of the intestine and the rotation of the stomach are the chief obstacles in unravelling the course and reflections of the peritoneum. About the beginning of the third month the ileo-cæcal valve is discernible, and the colon, first lying to the left of the small intestine, gradually crosses over their upper part, and, steadily growing in length, assumes about the fifth month after birth its normal position. The mesentery about the largest intestine is variously arranged and prolonged during the growth of the abdominal organs of the fœtus, and many congenital defects and abnormal conditions offer the best means of explaining what are usually described as its normal relations. In this connection it should be noted that there are many important changes which occur in the small and the large intestine in childhood depending upon growth and which necessarily cause modifications in the arrangement of the peritoneum. The small intestine at birth measures about two and nine-tenths metres, or nine and a half feet, and it grows about one and one-fifth metres, or four feet, in the first two months. It has been shown (Treves) that the cæcum and colon at birth measure thirty and one-half centimetres, or one foot, exclusive of the sigmoid flexure, which is about twenty-five and one-half centimetres, or ten inches, in length. This portion of the bowel does not increase in length until after the fourth month.

The peritoneum is a continuous serous membrane constituting in the male a perfectly-closed sac. It is so disposed that its *parietal layer*

lines the cavity of the abdomen and its *visceral layer* is reflected more or less over the viscera. The internal surface of the peritoneum is smooth and glistening, and lined by squamous epithelium; the external surface is composed of areolar tissue, the *subperitoneal tissue,* which connects the membrane with the viscera or the parietes. There is only a little moisture secreted in the sac between the two layers, which serves to furnish the smoothness of its surface and enables the viscera to glide easily over one another. The viscera are variously invested by the peritoneal sac. Some, as the pancreas, the kidneys, and the supra-renal capsules, are altogether outside and behind it; others, as the lower portions of the duodenum, the cæcum, and the ascending and descending colon, are only partially covered by it; while the stomach, liver, jejunum, ileum, transverse colon, and sigmoid flexure of the colon are completely invested by it. The latter, as they undergo changes in their development, cause the visceral layer to assume folds, which proportionately regulate the degree of mobility of their proper viscera.

The *course of the peritoneum in the adult* can be traced from any point throughout its continuity, but the author has found its demonstration most readily comprehended by commencing at the umbilicus, as follows. If the abdominal wall is opened and the parietal layer of the peritoneum exposed, as in Plate 56, it can be followed downward to the pubes, where it leaves the anterior abdominal wall to cover the upper and back part of the bladder, whence it is reflected upon the upper portion of the rectum in a loose fold called the *recto-vesical pouch* (Plate 74, Figs. 1 and 2). If the cavity of the peritoneum is then opened by slitting up the parietal layer so that it can be manipulated with both hands, the membrane will be noticed to present in the pubic and inguinal regions the slight folds about the obliterated urachus and hypogastric arteries already described (page 18). In the female the peritoneum is reflected from the bladder over the uterus and the upper part of the vagina, and thence to the upper portion of the rectum, thus forming respectively the *vesico-uterine pouch* and the *recto-uterine pouch* (*of Douglas*) (Plate 73, Figs. 1, 2, 3, and 4). From the sides of the uterus to the sides of the pelvic cavity the peritoneum is extended in double folds, constituting

the *broad ligaments* of the uterus (Plate 71, Fig. 2). The peritoneum, after surrounding the upper portion of the rectum as the *mesorectum* (page 37), is continued upward, in both sexes, on the posterior wall of the abdomen as far as the trunk of the superior mesenteric artery, along which it is continued to enclose the coils of the small intestine (jejunum and ileum), forming the *mesentery*. Laterally, the parietal peritoneum extends outwardly to the ascending and descending colon, which it invests in front and at the sides as the *mesocolon*, and then passes inwardly over the kidneys to the spine, where it is continuous with the layer already traced upward from the rectum to form the mesentery. In the right iliac region it covers the commencement of the cæcum and the vermiform appendix, and in the left iliac region the sigmoid flexure of the colon, forming the *sigmoid mesocolon*. Above the mesentery the peritoneum is reflected to the spine in relation to the lower part of the duodenum (which it helps to fix in position), and is thence extended to and about the transverse colon, forming the *transverse mesocolon*. This is directly continuous on each side with the ascending and descending mesocolon.

If we now return to the umbilicus and trace the parietal peritoneum upward, it will be found to extend over the under surface of the diaphragm, and to descend thence to the liver, which it invests upon its upper surface, its thin anterior edge, and the anterior part of its under surface. From the transverse fissure of the liver it passes to the smaller curvature of the stomach, forming the *anterior layer of the lesser omentum* (page 35). It is continued over the front of the stomach to the convex border, whence, as the *outer layer of the great omentum* (page 33), it is prolonged downward to a variable extent, doubles upon itself, and ascends to blend with the transverse mesocolon, from which it continues upward over the pancreas and the back wall of the abdomen to the posterior part of the under surface of the liver, at the transverse fissure of which it is reflected back to the stomach, forming the *posterior layer of the lesser omentum*. This passes over the posterior wall of the stomach to its convex border, where it becomes the *inner layer of the great omentum*, and thus is continued back again to the transverse mesocolon. Careful

consideration of the latter will show that there are therefore five peritoneal layers in front of the transverse colon,—viz., the four layers of the great omentum and the independent primary layer of the transverse colon. In the adult the latter is generally fused with the posterior outer layer of the great omentum, but when the transverse colon is not fixed in its usual position the several layers are arranged as above described.

There has been much confusion in the ideas of anatomists regarding the provision of a distinct duplicature of the peritoneum in the formation of the transverse mesocolon. This is certainly the general arrangement in the fœtus, and often in the young child before the viscera are fully developed and have attained their normal positions; and that the condition of this part of the peritoneum in the adult has given rise to so much discussion is probably due to the different points of view from which it has been examined.

The transverse mesocolon presents different relations to the posterior layer of the great omentum on either side of the middle line. On the right side its usual arrangement is such that there is little trace of the primitive peritoneal layer, but toward the left it becomes more manifest, and in the neighborhood of the splenic flexure it is usually pronounced. The author has never seen a diagram of any of the ideal transverse and median sections which made this subject comprehensible, and he believes that nothing short of an actual demonstration will convey a correct impression.

It should be understood that the *greater cavity of the peritoneum* is opened when the parietal layer is slit up to examine the reflections as above described. The greater cavity is external to the great omentum. The *lesser cavity of the peritoneum* may be regarded as the space within the doubled layers of the great omentum. It extends upward behind the stomach, and can be distended artificially by inflation through the *foramen of Winslow*, the opening by which the greater and lesser cavities communicate. The position of the foramen of Winslow, at the right border of the lesser omentum, has already been described (page 20), as well as the manner of its formation (page 29).

The several portions of the peritoneum which have important dis-

PLATE 57.

The anterior parietal layer of the peritoneum removed to show the great omentum fully developed and covering completely the intestines; also the relations of the liver, gall-bladder, and stomach to the cartilages of the lower ribs.

1. The cartilage of the right sixth rib.
2. The cartilage of the right seventh rib.
3. The left lobe of the liver overlapping the stomach.
4. The lower margin of the right lobe of the liver.
5. Remnant of the round or suspensory ligament of the liver.
6. The fundus of the gall-bladder in relation to the cartilage of the right ninth rib.
7. One of the vessels of the omentum.
8. The right spermatic cord.
9. The stomach.
10. The great omentum.
11. The lower portion of the great omentum covering the pelvic viscera.
12. The sub-peritoneal layer of fatty tissue.

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tinctive features are, briefly, the following. The *great omentum* (*gastro-colic omentum*) (Plate 57) consists of two double layers, proceeding from the convex border of the stomach downward to a variable extent and then turning upward upon themselves to the transverse colon. In some bodies the great omentum extends into the pelvis, and often becomes involved in herniæ; in others it is gathered in a bundle along the transverse colon. Its thickness varies considerably, and in a measure corresponds with the general development of the individual. In corpulent persons it is loaded with fat and contributes to the apparent size of the abdomen. In emaciated subjects it is translucent and presents a delicate lace-work appearance.

The *lesser omentum* (*gastro-hepatic omentum*) extends between the transverse fissure of the liver and the concave border of the stomach. It consists of two layers, which include the portal vein, the hepatic artery, the nerves distributed to the liver, and the hepatic duct and lymphatic vessels coming from it. These structures are surrounded by a loose areolar tissue, called the *capsule of Glisson* (page 53).

The *gastro-splenic omentum* is in reality an upward prolongation of the great omentum. It encloses the vasa brevia, which pass from the splenic artery at the concave surface of the spleen to the greater cul-de-sac of the stomach, and the gastro-epiploica sinistra artery. The spleen is also invested for the most part by a lateral expansion of the parietal peritoneum, duplicatures of which at the hilum connect it with the adjacent diaphragm and are called the *phreno-splenic ligament* and the *posterior splenic ligament.* In the folds of the former are enclosed the splenic artery and the splenic vein. The omenta, besides being composed of double layers, present peculiarities of structure which distinguish them from the rest of the peritoneum. They are always fenestrated, the meshes being connected by broader or narrower bands of fibrous tissue, and containing numerous vessels, lymph-spaces, and masses of fat.

The mesentery is the fold of the peritoneum which is attached to the back wall of the abdomen, extending from the left side of the second lumbar vertebra obliquely across the spine to the right sacro-iliac symphysis. It surrounds the coils of the jejunum and the ileum, and

between the layers of its pedicle are the branches of the mesenteric vessels, nerves, and lacteals. When spread out it is fan-shaped. It is connected with the transverse mesocolon above, and with the mesocolon in relation to the inner part of the cæcum below. In consequence of the oblique attachment of the root of the mesentery, when a vessel is wounded in the abdomen on the right side the blood is found in the right iliac fossa, while if a vessel is wounded on the left side the blood is found in the cavity of the pelvis. Slits sometimes occur in the layers of the mesentery, into which a loop of the intestine may find its way and become strangulated.

It has been suggested that an abnormally long mesentery may predispose to herniæ; and it is certain that the peritoneum will allow of very considerable stretching if the force is gradually exerted. It is constantly brought to the surgeon's attention that the peritoneum is particularly liable to become inflamed from any source acting upon its inner surface, such as perforation of the small intestine, but that its outer surface is comparatively exempt, as in the many forms of abscess which occur in the subperitoneal tissue.

The *transverse mesocolon* is the broad fold which connects the transverse colon with the back of the abdomen, and in a measure separates the stomach, liver, and spleen from the convolutions of the small intestine. The branches of the colica media artery ramify between its layers. The transverse colon is attached to the abdominal surface of the eleventh rib by a special thin fold of peritoneum called the *pleuro-colic fold.* The *ascending* and *descending mesocolon* respectively cover the right and left portions of the colon, upon their anterior and lateral surfaces. Posteriorly there is usually a broad part of the large bowel in each loin which rests upon the *lumbar fascia* without any intervening peritoneum. This is especially the case upon the right side, and is taken advantage of in the operation of *colotomy* for artificial anus in stricture of the rectum (page 219). Occasionally, however, the ascending and descending portions of the colon are provided with a distinct mesocolon. The *sigmoid mesocolon* generally completely surrounds the sigmoid flexure of the colon, which it fastens in a loose thin fold to the left iliac fossa. Owing

to the change in this part of the colon in the adult from that of the simple flexure it presents in early life, the sigmoid mesocolon is usually extended upward along the inferior mesenteric artery, forming the *inter-sigmoid pouch.* This may explain some of the symptoms attending habitual constipation. The *mesorectum* is the reflection of the peritoneum which surrounds the upper portion of the rectum and holds it in place against the sacrum. It includes the rectal or hæmorrhoidal vessels between its layers. The other folds and reflections of the peritoneum which constitute the *visceral ligaments* will be found described with the respective organs as they are studied separately when removed from the body.

The general anatomy of **the stomach**, including its shape, dimensions, and relations, has been studied with the organ *in situ* (page 23). After it has been moderately inflated and the lower part of the œsophagus and the upper part of the duodenum ligated, it can be removed, so as to afford better opportunity for examining the structure of its walls. The average specimen measures twenty-nine centimetres, or about twelve inches, in length, and twelve and a half centimetres, or about five inches, in width. Its weight is four and a half ounces. It has four coats,—the serous, the muscular, the submucous, and the mucous. The *serous coat* is derived from the peritoneum (page 30). It is closely adherent, and is complete except at the concave and convex borders, where the gastric vessels course between the layers as these pass to form the different omenta. A fold of the peritoneum is reflected about the left side of the œsophagus: it connects the stomach with the diaphragm, and is called the *gastro-phrenic ligament.* The *muscular coat* is exposed upon removal of the peritoneum, and consists of three strata of variously-disposed fibres of the unstriped variety. The outer layer, composed of *longitudinal* fibres, is more distinct along the concave border than along the convex, and is continuous with the similar layer of fibres upon the œsophagus above and upon the duodenum below. About the pyloric end the layer of longitudinal fibres is uniform, and at the sides is augmented by bands of connective tissue (*ligaments of Helvetius*) which produce the *antrum pylori.* The middle layer consists chiefly of *circular* fibres, and

the inner layer of *oblique* fibres. The latter are continuous with the circular fibres of the œsophagus, and are most pronounced about the œsophageal end of the stomach, crossing obliquely from right to left, and *vice versa,* and becoming scattered over the middle of the stomach, upon which the circular fibres are well marked. At the pyloric end the layer of circular fibres suddenly becomes thickened and produces the *pyloric sphincter.* The intimate association of the diaphragm with the œsophageal opening naturally obviates the necessity of a special sphincter at the cardiac end, although sometimes there is a valvular appearance which is probably due to the normal closure of the œsophagus and to prolapsus of the œsophageal mucosa. The *submucous coat* is a whitish areolar layer loosely connecting the muscular and mucous coats, so that they can move freely on each other. This layer may be regarded as the proper *vascular tunic* of the stomach, because within it the arteries break up into minute branches before they enter the mucous coat and the radicles of the veins commence. It also contains plexiform lymphatics and the filaments of the gastric nerves. The *mucous coat* is the lining membrane of the stomach, which must be laid open from end to end to expose it. It usually appears in the healthy state of a pale-pink or reddish-gray color. It is soft and thick like velvet, and folded into wrinkles, or *rugæ,* in its long diameter. These disappear when the organ is distended. The mucous membrane is thinnest at the fundus and thickest at the pylorus. In old age it appears to have thinned throughout, as if worn by use.

When examined with the microscope the entire area of the mucous membrane appears to be covered with small polygonal depressions (alveoli), in the bottom of each of which is seen the round orifice of a tubular gland, or *gastric follicle.* The alveoli are separated by slight ridges which are provided with villous processes. On section of the mucous coat the tubular glands are found to be proportioned in length to the thickness of the mucous membrane, being shortest at the cardiac end and fundus and longest at the pyloric end. At either end of the stomach they present further characteristic differences, which have led them to be distinguished as cardiac (or peptic) glands and pyloric glands. The *cardiac gastric glands* have short ducts, which soon become narrow

and communicate with several straight or slightly tortuous blunt-ended tubules. The *pyloric gastric glands* have longer ducts, with a larger passage than that in the ducts of the former, and they also become narrow and communicate with similar tubules. The ducts of both kinds of glands are lined with an extension of columnar epithelium like that of the gastric surface. In the cardiac glands there are in addition some scattered cells, which are called *parietal cells*, because they have their bases resting on the basement membrane. Each of these is peculiar in having a clear, oval nucleus. The gastric epithelium rests on a very delicate fibro-connective tissue augmented by the *muscularis mucosæ*, which consists chiefly of circular fibres except toward the pylorus, where the fibres have a longitudinal course. There are many *lymph-paths* which communicate with the lymphatic plexuses in the submucous coat, and which pass to the superficial and deep sets of lymphatic glands situated along the curvatures of the stomach.

The *arteries of the stomach* (Plate 61) are derived from the gastric, the vasa brevia, the right and left gastro-epiploica, and the pyloric arteries. They have already been described (page 23). Their arterioles penetrate from the submucosa between the glands and furnish a superficial capillary plexus and a deeper interglandular plexus. The beginnings of the *veins* are fewer and much larger than the arterioles. The venous radicles terminate in trunks, of which those corresponding to the gastric and pyloric arteries empty their blood into the vena portæ, and those which correspond to the vasa brevia and the epiploicæ arteries open into the splenic vein. The branches of the *right* and *left pneumogastric nerves* descend from the concave border of the stomach and interlace everywhere with the branches from the *sympathetic solar plexus*, forming the *gastric plexuses* (*of Auerbach* and *of Meissner*) in the muscular and mucous coats. The *pylorus* (page 22) is formed by the mucous membrane constricted by the layer of circular muscular fibres alone. Its lumen usually measures sixteen millimetres, or about two-thirds of an inch, in diameter. The circular fibres act like a sphincter in closing the opening, which toward the stomach is oblique and toward the duodenum is round. It is noteworthy that at the pylorus the alveoli of

the stomach stop and the villous mucosa of the intestinal canal begins. The *gastric juice* is a clear, viscid liquid with a peculiar acid taste. It is secreted from the epithelium and glands of the mucous membrane of the stomach, and consists chiefly of *pepsin* in solution with hydrochloric acid and mineral salts.

The small intestine consists of the duodenum, the jejunum, and the ileum, and is, when removed from the body, six metres, or about twenty feet, in length in the adult. The extent and relative position of the duodenum (Plate 61) are described on page 25. The jejunum to external appearance resembles the duodenum, being like it more vascular and its wall feeling thicker than that of the ileum, in consequence of the arrangement of the mucous coat, but there are no defined limits between the lower portions of the small intestine. Their outward characteristics are signified by their names, that of jejunum being given to the upper portion, which is usually found *empty* after death, and that of ileum to the lower part, which is especially *twisted* into coils. Like the stomach, the small intestine has four coats,—the serous, the muscular, the submucous, and the mucous. The peritoneum furnishes the *serous coat*, which, except in regard to the descending and transverse portions of the duodenum, forms a complete investment. The *muscular coat* consists of an outer longitudinal layer and an inner circular layer, the latter being the thicker of the two until near the termination of the ileum in the cæcum, where it is very thin. The *submucous coat* intervenes between the muscular and the mucous coat, and in immediate relation to the latter it is provided with a delicate layer of non-striped muscular fibres, called *muscularis mucosæ*.

The *mucous coat of the small intestine* is well worthy of careful study. In order to see it, the bowel should be removed, washed, and laid open. It then appears arranged in *transverse* folds, called *valvulæ conniventes*, which are best marked along the anterior wall of the duodenum. They extend about one-half or two-thirds round the bowel, but never encircle it. They are not of equal size, and project nine millimetres, or about one-third of an inch. They do not disappear when the tube is distended, as do the similar folds of the mucous lining

of the œsophagus and the stomach. The valvulæ conniventes are most developed in relation to the opening of the biliary and pancreatic ducts in the inferior angle of the duodenum (page 25). The orifice of the bile-duct is surmounted by a hood-like fold (the *caruncula major*). The bile-duct (page 55) takes a very oblique course through the wall of the duodenum before it opens, and from the opening there extends downward a small vertical fold, called the *frænulum.* The valvulæ conniventes become farther apart and gradually diminish in size until they disappear about the middle of the ileum. The entire mucous lining of the intestine presents small vascular processes, the *villi,* which can be readily seen by floating a portion of the bowel in water. Under the microscope a single villus is found to consist of an outer layer of epithelium superposed on a basement layer, under which are polygonal connective cells traversed by capillary vessels which return their blood by a single venous radicle. The axis of the villus is occupied by one or two lymph-canals which begin in a closed end near the top of the process, where it is enclosed by fibres from the muscularis mucosæ. The lymph-canals are the beginnings of the *lacteal* or *absorbent vessels.* In all parts of the villus there are numerous *amœboid lymph-cells* with oval nuclei. It has been estimated that the small intestine contains four millions of villi. The valvulæ conniventes being covered both on their upper and on their lower surface greatly increase the absorbent surface over which the *chyme* passes. Most of the particles of fat contained in the food are supposed to be absorbed by the villi and carried into the system by the amœboid cells.

Throughout the small intestine between the villi are variously placed four kinds of *intestinal glands,* severally known as the glands of Lieberkühn, of Brunner, of Peyer, and the solitary glands. The most numerous are the *simple follicles of Lieberkühn.* They are distributed over the large as well as over the small intestine, and consist of simple tubular mucous glands having blind ends. Their orifices appear under the microscope like dots or puncta between the villi. The *glands of Brunner,* or *duodenal* glands, are found chiefly close to the pylorus, and in structure resemble enlarged pyloric glands. The *glands of Peyer* (*glandulæ*

PLATE 58.

The convolutions of the small intestine as they normally appear upon opening the abdomen and reflecting upward the great omentum and the transverse portion of the colon.

1. The under surface of the great omentum, which is turned upward to show the intestines *in situ*.
2. The transverse colon, with appendices epiploicæ.
3. The transverse mesocolon.
4. The cæcum (lying just within the crest of the right ilium).
5. A coil of small intestine (*ileum*) in the right iliac fossa.
6. The bladder (partially distended).
7. A coil of small intestine (*jejunum*).
8. The descending colon.
9. Coils of small intestine (*ileum*).
10. A coil of small intestine (*jejunum*) in the left iliac fossa.
11. A portion of the (so-called) sigmoid flexure of the colon.

Plate 58

Vol. II

[illegible] Photographed and Colored from Nature by George McClellan M.D.

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agminatæ) are found in the lower part of the jejunum, but especially throughout the ileum. They are most distinctly seen in children. They are arranged in aggregations or groups, about thirty in number, on the border of the intestine opposite the attachment of the mesentery. In the jejunum they appear circular, and in the ileum as longitudinally-extended patches, so that they are often called *Peyer's patches.* They measure from one to seven centimetres, or from half an inch to three inches, in length, and from two to twelve millimetres, or from a few lines to half an inch, in width. They are usually destitute of villi on the surface, but contain many lymphoid nodules. They are surrounded by close rows of villi and simple follicles. These patches diminish in number and lose their distinctness as age advances. They are peculiarly susceptible to disease, as in typhoid fever, when they become enlarged and are liable to ulceration, often perforating the intestine. When the muscular coat is removed from over one of these patches in the normal state, it appears to consist of a number of oval flask-shaped vesicles embedded in the submucous tissue. The vesicles are ductless, and appear to discharge their contents—a grayish fluid—by rupture of their capsules. The *solitary glands* are scattered lymphoid nodules, resembling a single one of the component nodules of the glands of Peyer.

Around each solitary or agminated gland there is a minute net-work of blood-vessels and lymphatic vessels. The latter pierce the muscular coat and join with the outer set of intestinal lymphatics, which run between the layers of the longitudinal and the circular fibres.

The *lymphatic vessels of the intestinal canal* are called *lacteal vessels* because they appear of a milky-white color, in consequence of the admixture of the fatty products of digestion with the ordinary *intestinal juice,* which is derived from the epithelium and glands of the mucous membrane. This combination produces a nutritive liquid which is emulsified lymph and is called *chyle.* The lacteal vessels are constantly engaged in carrying it into the circulation. After leaving the small intestine the lacteals pass to the lacteal glands, of which there are over two hundred, in the layers of the mesentery.

The *arteries supplying the small intestine* are the branches which

arise from the convexity of the superior mesenteric artery (Plate 59), and which freely inosculate over the surfaces of the bowel, as described on page 21. The upper portion of the duodenum is supplied by the *gastro-duodenal branch of the hepatic artery* (Plate 60, No. 9). The *veins* accompany the arteries and empty into the superior mesenteric vein (Plate 59), which with the splenic vein forms the vena portæ behind the pancreas. The *nerves* of the intestinal wall are derived from the superior mesenteric plexus of sympathetic nerves which accompany the distribution of the arteries in the layers of the mesentery. The nerve-filaments separate from the arteries on reaching the wall of the bowel and pierce the layer of longitudinal muscular fibres, forming the *plexus mesentericus of Auerbach.* From this plexus filaments extend into the submucosa, where they again form the *plexus of Meissner*, in the same manner as in the walls of the stomach.

The large intestine consists of the cæcum, the colon, and the rectum, and measures in the adult about one and a half metres, or from five to six feet, in length. But all measurements can be considered only approximative, as the longitudinal muscular fibres are easily damaged in removing the bowel from the body, so that it is more or less lengthened. The relative positions of the different portions are described as they appear in the body (pages 25, 27, and 45), and are shown in Plates 58, 59, 61, 72, and 73. Considered as a whole, the large intestine forms a great loop. Beginning at the cæcum in the right iliac fossa, it first ascends to the liver, then, arching across to the spleen, it descends to the left iliac fossa, whence it passes into the pelvis to terminate at the anus. Almost all of the large bowel which is contained within the abdomen is accessible to pressure through the surface wall, and in cases of collection of flatus giving rise to colicky pains (*tormina*) much relief can be afforded by gently rubbing over the course of the colon. Throughout its course the large intestine is thicker and less vascular than the small intestine. Its principal external features are that it is pouched, or *sacculated*, and that it has attached to it little pendulous portions of fat covered with peritoneum, called *appendices epiploicæ*. The latter are always especially noticeable along the free border of the transverse colon

(Plate 58, No. 2). The *sacculi* are maintained by the longitudinal muscular fibres being arranged in three separate bands, the *tæniæ coli*, although they probably originate in consequence of the fæces as they become hardened causing a bulging of the intestine and thus a separation of the longitudinal muscle-fibres into the tæniæ. If the tæniæ are severed, the sacculi at once disappear and the bowel is proportionately lengthened. The mucous membrane of the large intestine is destitute of villi, valvulæ conniventes, and glands of Peyer, but there are abundant simple follicles and solitary glands which are larger than those in the small intestine.

If the **cæcum** is inflated after having been thoroughly washed, its peculiar shape and the external relations of the termination of the ileum and the vermiform appendix can be noted; but the preparation must be dried before examining the interior, which can then be best done by cutting away the fundus below the iliac orifice. This will give a view of the valves (Plate 65, Fig. 5, Nos. 5 and 6); also of the ridges or incomplete shelves of the mucous membrane, which correspond to the grooves (*plicæ sigmoideæ*) on the external surface. The latter disappear, like the sacculi, when the longitudinal bands are divided. The orifice of the ileum appears like a button-hole with two nearly parallel margins: the upper one, projecting more than the lower, is called the *ileo-colic valve;* the lower one, ascending obliquely beneath the upper, is called the *ileo-cæcal valve.* Each valve is formed by a duplicature of the mucous, submucous, and circular muscular layers. They can be unfolded by dissecting away the longitudinal fibres and the peritoneum. It is interesting that the mucous covering of the valves toward the ileum is provided with villi, while that toward the cæcum is without them. The vermiform appendix (page 27) has a continuous coat of longitudinal and circular muscular fibres, and its mucous membrane possesses numerous lymphoid follicles.

The rectum is best examined *in situ*, and its relation to the sacrum can be seen in sections of the pelvis (Plates 73 and 74). In the adult it is situated entirely within the true pelvis, while in the infant its upper portion is in the false pelvis, or lower part of the abdomen. In

the latter it is also nearly straight, but in the former it presents three marked curves, one lateral and two antero-posterior, as follows: it commences opposite the left sacro-iliac symphysis, curves slightly to the right of the middle line, and then descends, adapting itself to the shape of the sacrum and coccyx, and at the tip of the latter it bends backward to terminate in the anus. The rectum is cylindrical. It is narrowest at its upper part, and gradually increases in size toward the anus, immediately above which it presents a dilatation, the *ampulla analis*, capable of being enormously distended. The rectum is about twenty centimetres, or eight inches, in length, and its upper portion is entirely invested with the mesorectum (page 37). Anteriorly the *recto-vesical pouch of the peritoneum* (page 31) is within from seven to ten centimetres, or from two and a half to four inches, of the perineum. Posteriorly the peritoneum does not come within nine centimetres, or three and a half inches, of the anus (page 128). The muscular coat of the rectum differs from that of the cæcum and colon in that its longitudinal layer completely surrounds it, and that both the longitudinal and the circular fibres are well developed, resembling those of the œsophagus.

The longitudinal fibres become lost in the connective tissue about the anus. They are augmented by a band of fibres which extend on each side from the second coccygeal vertebra to the margin of the rectum,—the *recto-coccygeus muscle.* The circular fibres become thickened about six millimetres, or about a quarter of an inch, from the anal orifice, forming the *internal* or *deep sphincter ani muscle.* The *external sphincter ani muscle* is described with the perineum (page 160). The mucous membrane of the rectum is very vascular and thick, and so loosely attached to the muscular coat that in children, in whom the bowel is also straighter, as stated above, it predisposes to *prolapsus.* There are three permanent semilunar folds of the mucous membrane (*Houston's valves*). The first, situated opposite the prostate gland (page 134), projects backward, the second, opposite the middle of the sacrum, projects inward from the left side, and the third, near the commencement of the bowel, projects from the right side. The middle one is always the most prominent. When the rectum is empty the mucous membrane appears folded longitudinally

(*columnæ recti*), and at the verge of the anus is gathered into looped folds, called the *valvulæ Morgagni.* The anus (page 159) appears on section to have a stellate lumen.

The *arteries which supply the cæcum and the colon* are the branches from the right border of the superior mesenteric artery (Plate 59) and the branches of the inferior mesenteric artery (Plate 60): they are the *colica media, colica dextra, colica sinistra, colica sigmoidea,* and *ileo-colic arteries.* The *veins* from the different portions of the colon join the inferior and superior mesenteric branches of the portal system. The rectum has a special blood-supply from three diverse sources. The *superior rectal* or *superior hæmorrhoidal artery* comes from the inferior mesenteric artery (Plate 60, No. 31), the *middle rectal* or *middle hæmorrhoidal artery* from the anterior root of the internal iliac artery (Plate 76, Fig. 1, No. 7), and the *inferior rectal* or *inferior hæmorrhoidal artery* from the internal pudic artery (Plate 77, Fig. 1, No. 31, and Plate 79, No. 12). The disposition of the arteries in the lower part of the rectum is very peculiar. They pass parallel to one another toward the anus and freely communicate by large transverse branches. The veins are similarly arranged, and establish the *hæmorrhoidal venous plexus* about the lower end of the rectum. The main trunks from the latter are the *superior hæmorrhoidal veins,* tributaries of the inferior mesenteric vein, and the *middle* and *inferior hæmorrhoidal veins,* which terminate in the internal iliac veins, so that the portal and general venous systems are brought into direct communication. To this fact is chiefly attributed the tendency of the veins about the anus to become varicosed, and to the formation of piles or hæmorrhoids.

The *lymphatic vessels* of the large intestine are very numerous. Those from the colon pass to the lymphatic glands situated along the attachment of the mesocolon, and of those from the rectum some pass to a few glands behind the bowel in the pelvis and others to the glands in the loins. The *nerves* of the colon accompany the branches of the arteries, and are derived from the superior and inferior mesenteric plexuses of the sympathetic system. The nerves of the rectum are derived from the inferior mesenteric, hypogastric, and sacral plexuses.

The lymphatic or **absorbent system** consists of numerous fine transparent *vessels* and nodular bodies or *glands*. Like the blood-vessels (page 293, Vol. I.), the main lymphatic vessels have three coats, an outer or adventitia, composed essentially of fibro-connective tissue, a middle or muscular, and an inner, composed of elastic tissue lined by endothelium. The latter is peculiar for the many irregularities it presents, being variously formed into projections, folds, or pocket-like *valves*, which in the larger lymphatic vessels are disposed in pairs so close upon one another that the vessels appear when distended like strings of beads. Throughout the body the lymphatic vessels are generally arranged in superficial and deep sets. The *superficial lymphatics* form intricate plexuses upon the surface of the various organs, and communicate freely with the *deep lymphatics*, which commence in the interstices of the tissues and follow the course of the blood-vessels. The primary lymphatic vessels are called *lymphatic capillaries*, and, like the capillary blood-vessels, are composed of a single endothelial coat. They originate either in the *lymph-paths*, or cellular spaces of the connective tissue (page 301, Vol. I.), or in the *perivascular* and *perineural* spaces, in relation to the sheaths of certain arteries or nerves, or by *stomata* upon the walls of the serous cavities, which are practically great lymph-spaces. The intestinal lymphatics, or *lacteals*, as already described (page 43), arise by closed extremities upon the villi of the mucous membrane of the intestinal canal.

In the course of the chief lymphatic trunks there are oval or rounded masses of a reddish-gray color, called *lymphatic glands*, which normally vary in size from that of a hemp-seed to that of an almond. The structure of these glands consists of a medullary pulpy mass of reticular tissue surrounded by a capsule composed of several strata of connective tissue containing some unstriped muscle cells. From the capsule septa extend inward, subdividing the mass into alveoli which communicate with one another and resemble very closely the *lymphatic follicles* as found in the digestive canal (page 43). The space between the portion of the medullary mass in each alveolus and its portion of the capsule constitutes a *lymph-sinus*, the lining layer of which is adenoid tissue containing leucocytes. The lymphatic vessels which enter the glands

are called *afferent*, in distinction from the *efferent*, which leave them. The afferent vessels usually divide into many branches before entering a gland, which they do at all parts of the periphery, and, losing their outer and middle coats, form a dense plexus in the layers of the capsule, whence they open into the lymph-sinuses and thus bring the lymph into contact with the medullary mass. The efferent vessels commence in the lymph-sinuses and emerge at a depression called the *hilum*, where the capsule is deficient, and which also gives entrance and exit to the arteries and veins peculiar to each gland. The efferent vessels after leaving the gland-structure unite and form the lymphatic trunks. The lymphatic glands are most numerous in relation to the larger blood-vessels of the neck, thorax, abdomen, and pelvis, and especially in the layers of the mesentery. In the axilla and groin they are grouped in clusters, and a few occur at the back of the head, the bend of the elbow, and the popliteal space. They are particularly described with the anatomy of each of these regions. It should be recognized here that the lymphatic glands are found chiefly wherever there is a series of converging lymphatic vessels, and where the motions of the parts which they drain are liable to subject the lymph-current to pressure. They are always largest in those localities which are most vascular.

The *lymph* is a transparent, pale amber-colored fluid, consisting of *lymph-plasma* and *lymph-corpuscles*. The latter are found to be most numerous in the afferent vessels. The lymphatic vessels eventually terminate chiefly at the junctions of the common jugular and subclavian veins in the root of the neck, by the thoracic duct on the left side and the lymphatic duct on the right, as described in Vol. I., pages 227, 318. There are, however, communications between the lymphatic vessels and the posterior tibial and internal iliac veins which should not be overlooked.

The liver.—The position of the *liver* as it appears upon first opening the anterior wall of the abdomen has already been referred to (page 21). Its relations should also be studied while the organ is in place. The liver occupies the whole of the right hypochondriac region, and

PLATE 59.

The layers of the mesentery are opened to demonstrate the branches of the superior mesenteric vessels.

1. The great omentum reflected.
2. The transverse colon.
3. The transverse mesocolon.
4. The colica dextra artery.
5. The superior mesenteric vein.
6. The colica media artery.
7. The caput cæcum.
8. A portion of the ileum.
9. A portion of the jejunum.
10. The superior mesenteric artery.
11. The colica sinistra artery.
12. The vasa intestini tenuis.
13. A loop of the jejunum.

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extends across the epigastric to a variable degree into the left hypochondriac (Plate 29, Vol. I., and Plate 57). Its upper convex surface is moulded to the arch of the diaphragm, being protected on the right side by the ribs and their cartilages from the seventh to the eleventh, and in front by the ensiform cartilage and the cartilages of the sixth, seventh, eighth, and ninth ribs. The liver rises and falls with the diaphragm in respiration, the upper surface of the right lobe reaching as high posteriorly as the level of the upper border of the eighth dorsal vertebra in forced expiration, while in forced inspiration it descends to the level of the ninth dorsal vertebra (Plate 82). The position of the organ also varies with the posture. In the adult when standing erect and breathing naturally the lower border follows a line drawn from the eighth left to the ninth right costal cartilage (Plate 27, Vol. I.). This line is lower in the female and in children of both sexes. In the recumbent position the liver gravitates backward, so that the lower edge cannot be felt beneath the cartilages of the ribs on the right ride. Percussion over the anterior surface of the body will reveal that the liver extends upward to a line crossing the lower end of the gladiolus or mesosternum, and on the right side to the level of the fifth chondro-sternal joint, and on the left side to that of the sixth (Plate 27, Vol. I.). Tight lacing, habitually employed, will displace the liver, and in extreme cases it may even be forced into the right iliac fossa. It should not be overlooked that the healthy liver is subject to considerable changes during life. The diaphragm separates the liver from the right lung, the thin margin of which descends in front of it as far as the seventh costal cartilage (Vol. I., page 322). In the middle line below the ensiform cartilage the liver is close to the abdominal wall, where it overlaps the stomach. The relation of the liver to the right lower ribs is of importance, because it may be seriously implicated when the ribs are fractured; and punctured wounds occurring through the right sixth or seventh intercostal space would involve the diaphragm, and not only open both the pleural and peritoneal cavities but also injure both the lung and the liver.

The liver is connected with the diaphragm by folds of the peritoneum which are called ligaments. The *right* and *left lateral ligaments* (Plate

64, Fig. 1, Nos. 3 and 6) are formed by the layers of the peritoneum over the surfaces of the liver being reflected at the ends of the posterior border. Extending between the lateral ligaments there is a broad part of the reflection, the *coronary ligament*, which receives the *suspensory* or *falciform ligament*. The latter crosses the surface of the liver in an oblique direction from the umbilicus (Plate 57, No. 5), and contains in its free border the cord resulting from the obliterated umbilical vein, which is called the *round ligament* (Plate 67, Fig. 3, No. 2). When removed from the body the liver will be found to weigh in the adult from fifty to sixty ounces. It measures from twenty-five to thirty centimetres, or from ten to twelve inches, in length, eighteen centimetres, or about seven inches, in breadth, and eight centimetres, or about three inches, in thickness. The liver is of a deep reddish-brown color, often mottled with purple. Looked at from above and when placed as it would be in the body (Plate 64, Fig. 1), its upper surface appears smooth and convex, with the fold of the peritoneum forming the suspensory ligament passing from behind forward and dividing this surface into the *right* and *left lobes*. The right lobe is much the larger. The anterior border is a sharp, thin edge, below which is seen the fundus of the gall-bladder. To the left of the latter there is a notch lodging the round ligament. The posterior border is rounded and thick and has the coronary and lateral ligaments attached to it. When the organ is reversed, so as to show its under surface, it will be seen to be concave and very irregular (Plate 64, Fig. 2), owing to being marked by five fissures which present somewhat the appearance of the letter **A** inverted. The right and left lobes are here seen to be divided by the *longitudinal fissure*, which contains the round ligament. It is deeper in front than behind, and frequently bridged over by liver-tissue (the *pons hepatis*). The *fissure for the ductus venosus* is the continuation backward of the longitudinal fissure, and contains the obliterated cord from the fœtal ductus venosus (Vol. I., page 304). The *fissure of the gall-bladder* is to the right of the longitudinal fissure. The *fissure for the inferior vena cava* passes obliquely to join the fissure for the ductus venosus at the posterior border of the liver. It is very often bridged across (Plate 64, Fig. 2, No. 19). The *transverse* or *portal*

fissure unites the other fissures and transmits the vessels into the substance of the liver.

Besides the right and left lobes there are three others, which may be considered as parts of the right lobe. The *lobulus Spigelii* is quadrilateral, placed between the fissures for the ductus venosus and the inferior vena cava and the transverse fissure. This lobe is joined to the right lobe by a narrow portion of liver-substance, the *lobulus caudatus*. The latter separates the transverse fissure from the fissure for the inferior vena cava. The *lobulus quadratus* is between the gall-bladder and the longitudinal fissure. It will be noticed that the posterior surface is deeply notched where it fits against the bodies of the dorsal vertebræ, and that it is indented by the inferior vena cava, to the right of which there is a shallow fossa, the *impressio renalis*, for the right kidney and supra-renal body. There is another fossa to the right of the gall-bladder at the anterior part of the lower surface, which receives the hepatic flexure of the colon, and is the *impressio colica*.

The liver is surrounded with a thin, firm, *fibrous coat*, which can be best seen where the peritoneal covering is deficient. It does not send inward prolongations through the substance of the organ, as is the case with similar coats of other glandular structures. It is, however, continuous at the transverse fissure with the sheath of areolar tissue called the *capsule of Glisson*, which loosely surrounds the vessels as they enter and issue from that fissure and encloses them throughout their ramifications. The relations which the vessels hold to one another at the transverse (or portal) fissure are (Plate 64, Fig. 2) the hepatic artery in front and to the left, the common bile-duct to the right, and the vena portæ behind and between these.

The liver-substance consists of an aggregation of minute polyhedral lobules, which are imperfectly marked off from one another by septa of areolar tissue. The lobules themselves consist of polyhedral epithelial cells (amœboid during life) containing nuclei held closely together by a sponge-like arrangement of capillary blood-vessels. It is interesting to note that the two different vessels, the *portal vein* and the *hepatic artery*, which convey the blood to the liver both enter at the transverse

fissure and break up into diverging branches, which accompany one another to their terminations at the periphery of the lobules.

The vena portæ, or *portal vein*, commences on the right of the body of the second lumbar vertebra, and ascends behind the head of the pancreas and the first part of the duodenum between the contiguous layers of the peritoneum to the right end of the transverse fissure of the liver. It conveys the blood which has been returned from the veins of the digestive canal, the *inferior* and *superior mesenteric veins*, and the blood from the *splenic vein*, which receives on its way from the spleen the *venæ breves* and the *left gastro-epiploic vein*, to be purified before it passes back into the circulatory system. The **hepatic artery** arises from the right of the *cœliac axis* (of the aorta), and passes to the left end of the transverse fissure of the liver, where it first gives off branches to the capsule of Glisson and to the fibrous coat, and then divides and subdivides within the substance of the organ. The hepatic artery conveys the blood destined to nourish the liver and to furnish it with the materials necessary for the performance of its proper function. The branches of the vena portæ are much larger than those of the hepatic artery. They are both ensheathed with the *hepatic ducts* in a common areolar investment, prolonged from the capsule of Glisson, and as they pass side by side in the interlobular septa are respectively called *vaginal branches*. From the vaginal branches of the vena portæ there arise *interlobular branches*, which pass between the lobules and form anastomosing plexuses around each cluster of hepatic cells. From these interlobular branches the blood is discharged into a centripetal *lobular capillary net-work*, whence it passes into the *intralobular veins*, which, beginning in the centre of each lobule, pass in their axes to empty into the *sublobular veins*. The latter are the commencements of the radicles of the hepatic veins. These unite to form three main trunks, which open into the inferior vena cava as this vessel passes through the posterior border of the liver. When a section of the liver is made, the branches of the vena portæ may be distinguished from those of the hepatic veins by their being accompanied by a vaginal branch of the hepatic artery and one of the hepatic ducts. The ultimate branches

of the hepatic artery are the interlobular capillary arteries, which join the interlobular capillary veins in the plexuses. The hepatic cells separate the bile from the blood, and discharge their contents into the biliary ducts. These commence as minute passages (*bile-canaliculi*) about the hepatic cells, and convey the bile into the vaginal hepatic ducts, which accompany the vaginal hepatic arteries and the vaginal branches of the vena portæ. The hepatic ducts converge to a right and a left main duct, which unite after leaving the transverse fissure into a single duct, the common bile-duct, or *ductus communis choledochus.* The latter is seven and a half centimetres, or three inches, in length, and the size of a quill. It descends in the lesser omentum in front of the vena portæ, and is crossed by the pancreatico-duodenalis artery as it approaches the middle of the second part of the duodenum. It pierces the outer coats of the duodenum, and passes obliquely just above the point of entrance of the greater pancreatic duct (Plate 65, Fig. 2, No. 15). The two ducts unite and open by a small common orifice upon the mucous membrane (page 41).

The *lymphatic vessels of the liver* are arranged in superficial and deep sets. The *deep* lymphatics commence in lymph-spaces between the hepatic cells and the capillary vessels, which communicate with nets of lymphatic vessels about the lobules and about the vaginal vessels and ducts. They join the lymphatic glands situated behind the pancreas and along the concavity of the stomach. Some lymphatic vessels also follow the branches of the hepatic veins. The *superficial* lymphatic vessels form a plexus over the surface of the liver beneath the peritoneum. Those on the upper surface pass to the anterior mediastinal glands, and those on the lower surface join the deep lymphatics as they emerge from the transverse fissure.

The *nerves of the liver* are remarkably small, and are derived partly from the cœliac or solar plexus of the sympathetic nerve, and partly from the *right pneumogastric nerve.* They mostly accompany the arteries and the ducts. Filaments of the *right phrenic nerve* pass to the right lobe through the folds of the coronary ligament, after passing through the sympathetic ganglion on the diaphragm (Vol. I., page 322). The pain

which is felt at the top of the right shoulder in diseases of the liver is conjectured to be due to the reflex influence through the phrenic nerve to the third and fourth cervical nerves, whence the supra-acromial nerves are also derived (pages 193 and 207, Vol. I.).

The *functions of the liver* are very important. It renders the albuminous matter which is conveyed to it by the vena portæ capable of being assimilated. It furnishes *glycogen*, a substance which is readily converted into sugar, and, passing out by the hepatic vein, assists in the production of animal heat. It secretes the *bile*, a bitter yellow liquid of alkaline reaction, which has the property of assisting the pancreatic juice in converting the chyme into chyle and rendering it fit for absorption by the lacteals. The bile acts also as a natural aperient, and probably exerts some antiseptic influence in preventing the decomposition of the food while in the intestinal canal.

The gall-bladder (Plate 64, Fig. 2, No. 17), or reservoir of the bile, is lodged in a shallow fossa on the under surface of the right lobe of the liver. When inflated, it appears as a pear-shaped body ten centimetres, or four inches, in length, and three centimetres, or an inch and a quarter, in width. It consists of a fundus, a body, and a neck. The *fundus* is covered with peritoneum, and projects downward below the anterior sharp edge of the liver in relation to the ninth costal cartilage (page 20) (Plate 57, No. 6). The *body* is immediately over the hepatic flexure of the colon, the pyloric end of the stomach, and the beginning of the duodenum. The *neck* becomes narrow and curves upon itself like the letter **S** before it ends in the *cystic duct* at the transverse fissure of the liver. As the fundus is the lowest part, the bile naturally flows into it in the ordinary erect positions of the body in the intervals of digestion. The cystic duct joins the main hepatic duct at an acute angle. The gall-bladder has a fibrous coat, containing some longitudinal and circular muscular fibres. The mucous membrane within the sac presents irregularly-depressed pits, separated by well-defined ridges, which are arranged in the neck into oblique folds (*valves of Heister*), which moderate the flow of the bile into or out of the reservoir. When the gall-bladder is distended the fluid is usually found to be chiefly mucous.

The gall-bladder is supplied by the cystic branch of the hepatic artery (Plate 61, No. 8), which has *venæ comites.* Gall-stones, which are concretions of cholesterin, are often found in the gall-bladder.

The comparatively enormous size of the liver in the new-born child has been referred to on page 1, and is well shown in Plate 66, Figs. 1 and 2.

The pancreas (Plate 61, No. 26) is a compound racemose gland placed on the posterior wall of the abdomen, behind the stomach and over the first lumbar vertebra. It is of a pinkish cream-color. It is very irregular in shape, and consists of a head, a body, and a tail. The *head* is closely attached to the curve of the duodenum (page 24), the superior and inferior pancreatico-duodenal arteries running between them. There is sometimes a prolongation upward from the under surface of this part of the gland, which is called the *lesser pancreas.* The *body* is covered by the posterior layer of the transverse mesocolon, and lies upon the aorta, the left crus of the diaphragm, and the left suprarenal capsule. The superior mesenteric artery and superior mesenteric vein come from under the body of the pancreas and pass over the transverse portion of the duodenum (Plate 61). The *tail* extends to the hilum of the spleen, and rests on the left kidney and its vessels. The pancreas is wholly behind the peritoneum. It has a delicate areolar capsule, which sends processes between and around its component lobules. It is richly supplied with blood by branches from the superior and inferior pancreatico-duodenal arteries on the right, and on the left by branches from the *pancreatica magna* and *pancreaticæ parvæ arteries* from the splenic artery. The *pancreatic veins* empty into the splenic and superior mesenteric veins. The *pancreatic duct* begins near the tail of the pancreas and passes along nearer its lower and posterior borders than its upper and anterior, receiving in its course numerous branches which come from the different lobules and enter it at right angles. It appears as a thin, whitish tube (Plate 65, Fig. 2, No. 14), gradually increasing in size until it reaches the head, where if there is a lesser pancreas it will be joined by its duct. It curves downward and approaches the wall of the descending portion of the duodenum in relation with the common bile-duct. There

PLATE 60.

The great omentum is removed and the layers of the mesentery opened to show the distribution of the branches of the inferior mesenteric artery. The transverse colon is drawn upward, exposing the relations of the duodenum to the liver and the stomach.

1. The right nipple.
2. The transverse colon, drawn upward.
3. The branches of the colica media artery, separated from its trunk.
4. Remains of the suspensory ligament of the liver.
5. The right lobe of the liver.
6. The gall-bladder, with the cystic artery.
7. The colica dextra artery.
8. The hepatic flexure of the colon.
9. The gastro-duodenalis artery.
10. The superior mesenteric vein (cut off).
11. The superior mesenteric artery (cut off).
12. The junction of the first and second portions of the duodenum (where the ductus communis choledochus opens into the bowel).
13. The transverse portion of the duodenum.
14. The cæcum (*caput coli*).
15. The bifurcation of the abdominal aorta into the two common iliac arteries.
16. The end of the ileum (tied and pulled aside).
17. The appendix vermiformis, in its usual position.
18. The commencement of the rectum.
19. The right vas deferens.
20. The right spermatic cord.
21. The suspensory ligament of the penis.
22. The left nipple.
23. The left lobe of the liver.
24. The fundus of the stomach.
25. The splenic flexure of the colon.
26. The gastro-epiploica sinistra artery.
27. The end of the duodenum (tied).
28. The inferior mesenteric artery.
29. The abdominal aorta, seen through the deep fascia.
30. The colica sinistra artery.
31. The superior hæmorrhoidal (rectal) artery.
32. The vasa intestini tenuis.
33. The sigmoid artery.
34. The sigmoid flexure of the colon.
35. The deep circumflex iliac artery.
36. The left spermatic cord.

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is occasionally a small *accessory pancreatic duct* (*of Santorinus*), which collects the secretion from some of the lobules on the upper portion of the head, and passes directly to the duodenum, opening into the mucous membrane of the intestine four centimetres, or about one and a half inches, above the common opening of the biliary and pancreatic ducts. The structure of the pancreas resembles very closely that of the salivary glands. The *pancreatic fluid* serves to emulsify the fatty particles of the food in conjunction with the bile, to convert starchy matters into dextrin and grape-sugar, and to convert into peptones the albuminous and gelatinous substances contained in the food. After death the pancreatic fluid softens the tissues in the posterior part of the gland, so that the pancreatico-duodenal arteries are very liable to rupture during the injection of a body for embalming. The *lymphatic vessels* of the pancreas pass to the lumbar lymphatic glands; the *nerves* are derived from the solar plexus.

The spleen (Plate 61, No. 25) has already been described as to its relations *in situ* (page 28). It is a dark-purple-colored, sponge-like organ, and varies in size, being usually twelve and one-half centimetres, or about five inches, in length. It is somewhat elliptical in shape, and when in position its long axis coincides with the line of the tenth rib. Its outer or costal surface is smooth and convex, while its inner surface is concave and divided by a vertical fissure—the *hilum*—through which the vessels enter and pass out. The hilum is connected with the stomach and with the diaphragm by folds of the peritoneum, called the gastro-splenic omentum and the posterior splenic ligament, already described (page 35). The splenic flexure of the colon is in relation to the lower end of the spleen. The spleen is classified with the thyroid body (Vol. I., page 233), the thymus gland (Vol. I., page 260), and the supra-renal capsules (page 67), each of which has no proper duct. Beneath the peritoneal covering of the spleen there is a *tough areolar coat* which sends inward various *trabeculæ*, which form a spongy skeleton for the support of the *splenic pulp*. This is a soft reddish-brown substance which under the microscope appears to consist of connective-tissue corpuscles with branching processes, *sustentacular cells*, between which the meshes are filled with red

and white blood corpuscles, the latter predominating. The cells have several nuclei, and possess amœboid movement.

The splenic artery is the largest of the branches of the cœliac axis, and passes in a remarkably tortuous course along the upper border of the pancreas (Plate 61, No. 27, and Plate 65, Fig. 2, No. 5) to the hilum of the spleen, where it terminates usually in five terminal branches. These can be best examined after removing the splenic pulp by maceration and floating the spleen in water. They will then appear to branch out into the trabeculæ. The microscope further shows that there is a fine mesh of adenoid tissue within the trabecular areolar tissue, into which the splenic arterioles pass, dividing minutely and ending in pencil-like sets of diverging branches which do not anastomose. The adenoid tissue which supports the arterioles dilates at points into oval nodules containing lymph-cells, which are called *Malpighian corpuscles.* They are visible in a fresh specimen, and appear like grayish specks. The terminal arterioles pour their blood into the pulp-tissue within the intercellular spaces, where the *venous radicles* arise. These unite to form the efferent veins, and, escaping at the hilum, empty their blood into the splenic vein, which contributes to the portal vein (page 53).

The *lymphatic vessels of the spleen* consist of superficial and deep sets, the former being under the peritoneum and passing to the lymphatic glands in the gastro-splenic omentum. The deep set, the *perivascular lymphatics,* arise in the adenoid tissue about the arterioles and accompany the venous radicles to the hilum, where they join the superficial set. The *nerves of the spleen* form the *splenic plexus.* They are derived from the solar plexus, and are distributed principally along the course of the vessels. The *function of the spleen* is obscure, but from the fact that the blood in the splenic vein contains a large excess of *white corpuscles* it is inferred that the organ is concerned in the production of the latter. It is a blood diverticulum, as it is always enlarged during digestion and after rapid exercise. The spleen is considered to resemble closely the lymphatic system in functional relationship.

The kidneys are the two nearly symmetrical glandular organs of a reddish-brown color on the back wall of the abdomen, one in the

right and the other in the left lumbar region (Plate 62). The right kidney is a little lower than the left, being depressed by the liver, and is situated at the sides of the last dorsal and upper three lumbar vertebræ. The left kidney usually reaches the lower border of the eleventh dorsal vertebra, and rarely extends as low as the third lumbar. The left twelfth rib crosses the back of the left kidney about one-third the distance from its upper border, and the right twelfth rib is usually about on a level with the top of the right kidney (Plate 84, Fig. 2). The convex outer border of each kidney corresponds to a vertical line ten centimetres, or about four inches, from the spines of the lumbar vertebræ, which also corresponds to the outer border of the quadratus lumborum and erector spinæ mass of muscles (Plate 84, Fig. 1). Posteriorly the kidneys rest upon a loose layer of fatty tissue, the *tunica adiposa,* which separates the organs from the subjacent attachments of the diaphragm and from the fascia over the quadrati muscles (Plate 63, No. 2). In front of the *right* kidney are the ascending portion of the colon and the descending portion of the duodenum. Above it is the right supra-renal capsule, and it is overlapped by the right lobe of the liver (page 51). In front of the *left* kidney are the tail of the pancreas, the fundus of the stomach, and the descending portion of the colon. Above it is the left supra-renal capsule, and it is overlapped somewhat by the lower end of the spleen. Both kidneys are wholly outside of the peritoneum, which covers their anterior surfaces to a variable extent. When the peritoneum is removed, the kidneys are seen (Plate 62) to be placed somewhat obliquely, so that their axes if prolonged upward would meet on the ninth dorsal vertebra, and if prolonged downward would pass over the tips of the crests of the ilia. Their outer borders are convex (sometimes undulating), and their upper extremities are slightly larger than their lower. They measure ten centimetres, or about four inches, in length, five centimetres, or two and a half inches, in breadth, and thirty-three millimetres, or one and a quarter inches, in thickness. The left kidney is usually the larger of the two. Their inner borders are concave, each presenting a longitudinal gap, the *hilum,* leading into the hollow, the *sinus,* for the entrance of the renal artery

and the exit of the renal vein and the ureter. The relations of these on the two sides should be noted (Plate 62). On the right side the renal vein is usually the highest. It is placed in front of the branches of the renal artery, some of which will be found above the vein on the left side. The ureter is behind and below the arteries. The renal vein is the only vein below the diaphragm which is *superficial* to the corresponding artery.

Upon removal from the body, each kidney (Plate 64, Figs. 3, 4, and 5) will be found to be provided with a strong fibro-elastic capsule, the *tunica albuginea,* which at the hilum is reflected inward, forming the sheaths of the vessels. Beneath the capsule there is a loose areolar-tissue layer containing some unstriped muscle-fibres. Upon longitudinal section (Plate 64, Fig. 5), the organ appears to consist of two kinds of tissue, a superficial, reddish-brown *cortical substance,* and a deeper, paler *medullary substance.* The latter is arranged in *pyramids* (*of Malpighi*) with their apices toward the hilum, and the former not only extends over the bases of these pyramids, forming the *cortical arches,* but also sends processes between them, the *cortical columns* (*of Bertini*). There are from eight to fourteen pyramids, each of which consists of minute radially-striated tubules which extend from the cortical substance at the base to the apex, or *papilla.* The several groups of papillæ project into short tubes, the *calyces,* and these unite to form two or three funnel-shaped channels, the *infundibula,* which open directly into the main cavity or *pelvis* of the kidney. The microscope shows that there are upon the mucous membrane over the surface of each of the papillæ, within the calyces, little depressions (*foveolæ*), each of which has from forty to sixty *puncta,* the orifices of the urinary tubules (*tubuli uriniferi*). From the bases of the pyramids in the medullary substance there are radial streaks, the *medullary rays* (or *pyramids of Ferrein*), between which are areas of connective tissue filled with reddish granulations, blood-vessels, nerves, and lymphatics, called the *renal labyrinths.* Within the labyrinths the tubules can be traced beginning as oval sacs (the *capsules of Bowman*). Each capsule has a constriction, the *neck,* which joins a tortuous tube (the *primary convoluted tube*) which passes to the nearest

medullary pyramid, becoming here known as the *spiral tube*, and descends to the base of the corresponding pyramid, where it becomes very minute and takes a vertical direction (the *descending tube of Henle*) to the papilla, then, suddenly turning backward (the *loop of Henle*) and dilating, it ascends (the *ascending tube of Henle*) to re-enter the labyrinth at the base of the pyramid. Here the tube can be traced twisting upon itself (the *irregular tubule*) and turning downward (the *secondary convoluted tube*) to join by a slender canal (the *junctional tube*) with the straight tube (*of Bellini*) which passes to the apex or papilla of the pyramid. Each straight tube, as it receives in its course many of the junctional tubes, is called the *collecting tube.* It has been estimated that there are about fourteen hundred of these at the base of each pyramid, but as they pass downward they join with one another, thereby diminishing their number to about sixty at the apex. Each of the capsules of Bowman above described contains a little arterial vascular tuft, the *Malpighian glomerulus.* Of these there are said to be about half a million in each kidney, and the length of the various tubes aggregates about fifteen miles.

The renal arteries arise from the aorta at right angles on the level of the first lumbar vertebra. They cross the crura of the diaphragm, the *right artery* passing *behind* the inferior vena cava (Plate 62, No. 4), and being the longer on account of the position of the aorta. The left artery is usually somewhat higher than the right. As each artery approaches the hilum of the kidney it divides into three or four branches. There is also very commonly an *inferior renal artery,* arising from the aorta and passing to the lower end of the sinus. This is seen in Plate 62, No. 25. The subdivisions of the branches of the renal artery enter the columns of the cortical substance, the *interpyramidal branches,* and upon reaching the cortex give off fine branches which form numerous arches (*arcis arteriosi*). From the convexity of the arches twigs pass to the surface-layer of tissue (*terminal branches*), while others pass backward straight through the pyramids (the *intrapyramidal branches,* or *arteriolæ rectæ*). The principal branches, however, are given off from the sides of the interpyramidal arteries as short curved branches.

They are the *afferent arteries* (*vasa afferentia*) to the capsules. The wall of each capsule appears to be invaginated by the special artery which approaches it, so that in breaking up into the looped capillaries, of which there are about twenty in each glomerulus, it provides them with a delicate supporting membrane. Close to the entrance of the afferent artery the *efferent vein* (*vas efferens*) makes its exit. It is smaller than the artery, and breaks up into a capillary venous plexus surrounding the convoluted uriniferous tubules. From these plexuses radicle *intrapyramidal veins* pass to join with one another in the pyramids and eventually terminate in the branches of the renal veins. Besides the efferent veins there are other veins, some arising from the capillary net-work of the surface of the organ and forming the *interpyramidal veins*, and the *venæ rectæ*, which pass outward in a straight course from the plexuses at the apices of the pyramids formed by the arteriolæ rectæ. All of these terminate in the branches of the renal vein.

The renal veins are large and short, and pass from the kidneys to enter the inferior vena cava at right angles. The left vein is the higher of the two, and is also the longer, on account of the position of the vena cava. It usually passes in front of the aorta below the superior mesenteric artery, and it is peculiar in that it receives the left spermatic vein (Plate 62, No. 24), which joins it at a right angle (page 149). Each renal vein receives the vein from the corresponding supra-renal body, which is guarded by a valve at its entrance. There is a very imperfect valve in the left renal vein, but hardly any traceable in the right.

The *lymphatic vessels of the kidney* are numerous, and consist of superficial and deep sets. The former is found in the meshes of the fibrous coat of the organ, and the latter is composed of a net-work of lymphatic spaces surrounding the uriniferous tubules. They join each other and terminate in the lumbar lymphatic glands.

The *nerves of the kidney* are derived from the renal plexus of the sympathetic nerve, and accompany the arteries, being apparently distributed only on their coats.

The kidneys of the fœtus are lobulated, and in young children the surface appears fissured, but as age advances the cortical substance gradually obliterates these markings, which represent the several pyramids. Occasionally there is only one kidney, and sometimes the organ on one side or the other is not encapsulated with fatty tissue, but is held in place merely by the blood-vessels and the ureter at its hilum. It is then called a "movable kidney." Sometimes the organ is invested with peritoneum (*mesonephron*) and becomes displaced into the general abdominal cavity, being checked only by its blood-vessels, so that it is called a "floating kidney."

The *function of the kidneys* is to separate from the blood, in addition to a large quantity of its watery principle, certain deleterious materials, which when dissolved in the water constitute the urine. It has been asserted that the epithelial lining of the various parts of the uriniferous tubules has not only characteristic features, but also the property of eliminating certain principles. Much of this is conjectural, however. It seems to be established that the water and saline parts of the urine are excreted into the capsules by transudation from the glomeruli, and that the tortuous tubules furnish the organic constituents.

The ureters are the membranous tubes which convey the urine from the pelves of the kidneys to the urinary bladder within the pelvis. They are generally thirty-five centimetres, or about fourteen and a half inches, in length, and from three to five millimetres, or from one-eighth to one-sixth of an inch, in diameter. They are behind the peritoneum, and when *in situ* (Plate 62, Nos. 10 and 32) appear as pale collapsed tubes descending on the psoas muscles and passing over the bifurcation of the common iliac arteries. In the lumbar region the spermatic artery and spermatic vein pass over the ureters as they descend into the pelvis, where they find their way in the layers of the peritoneum constituting the posterior false ligament of the bladder, to open into the base of that viscus, externally to the vas deferens in the male (page 150) (Plate 74, Fig. 2). In the female the ureters penetrate the plexus of uterine veins beneath the broad ligament (Plate 72, Fig. 2, No. 4). The walls of the ureters consist of three coats. The outer coat is composed of fibro-

PLATE 61.

The stomach is drawn forward and turned upward upon the anterior surface of the thorax, showing its curvatures and the branches of the cœliac axis. The transverse colon and the mesocolon are removed to display the relations of the pancreas to the duodenum and the spleen; also the cæcum and the vermiform appendix and the sigmoid flexure of the colon in their usual positions.

1. The gastro-epiploica dextra artery.
2. The *coronaria ventriculi* formed by the gastric artery.
3. The left lobe of the liver.
4. The pyloric extremity of the stomach.
5. The hepatic artery.
6. The gastro-duodenalis artery.
7. The portal vein.
8. The gall-bladder, with branches of the cystic artery.
9. The superior pancreatico-duodenalis artery.
10. The right lobe of the liver.
11. The inferior pancreatico-duodenalis artery.
12. The point of junction of the descending and transverse portions of the duodenum.
13. The bifurcation of the common iliac arteries from the abdominal aorta, covered with the deep fascia.
14. The appendix vermiformis.
15. The cæcum.
16. The termination of the sigmoid flexure of the colon in the rectum.
17. The right superficial circumflex artery.
18. The posterior surface of the stomach.
19. The gastro-epiploica sinistra artery.
20. The gastric artery.
21. The cœliac axis.
22. The inferior vena cava.
23. The splenic vein emptying into the portal vein.
24. The abdominal aorta, above the pancreas.
25. The spleen.
26. The head of the pancreas.
27. The splenic artery.
28. The superior mesenteric artery.
29. The superior mesenteric vein.
30. The end of the duodenum tied.
31. The colica sinistra artery.
32. The inferior mesenteric artery.
33. The sigmoid flexure of the colon.
34. The bladder distended.
35. The left superficial circumflex iliac artery.

Dissected, Photographed and Colored from Nature by George McClellan, M.D.

Armstrong & Co. Lith. Boston

connective tissue with elastic fibres. The middle coat consists of irregularly disposed longitudinal and circular muscular fibres. The inner coat is the mucous lining, which presents longitudinal folds and has a few mucous glands near the pelvis of the kidney. There are many lymphatic vessels, and a few arteries derived from the renal, lumbar, and common iliac arteries. The nerves come from the renal and hypogastric plexuses.

The supra-renal capsules, or **supra-renal bodies,** are two flattened, triangular, brownish-yellow glandular bodies surmounting the kidneys, on the posterior wall of the abdomen (Plate 26, Fig. 3, No. 8, Vol. I., and Plate 62, No. 2). They are embedded in a layer of loose areolar fatty tissue. Their posterior surfaces rest upon the diaphragm, and their anterior surfaces present a notch, or hilum, where the vessels enter and leave. The right supra-renal body is in contact above with the under surface of the liver, and the left one with the pancreas and spleen. The left supra-renal body is crescentic in shape, while the right is more triangular and usually smaller. They each measure about five centimetres, or two inches, in their longest diameter, and about two centimetres, or three-fourths of an inch, in breadth. Their size, however, varies with age, being always larger proportionately in the young child. The upper border of each is thin, and projects forward toward the middle line, while the lower border is concave, so that the bodies look not unlike two little cocked hats. They are each invested by an inelastic capsule, which sends inward processes—*trabeculæ*—through the outer layer of granular tissue which constitutes the *cortical portion.* There is a difference in the trabeculæ at different depths. At the surface the meshes appear polygonal and filled with granular cells, forming the *zona glomerulosa;* beneath this is a net-work of elongated meshes containing oil-globules, the *zona fasciculata;* and the innermost layer is a mesh-work containing brownish pigmented cells, the *zona reticularis.* All of these strata run into one another without clear definition. The *medullary portion* is soft and pulpy, and consists of a very delicate trabecular net-work filled with brown pigment-cells and many nerve-filaments having ganglion-cells. The *supra-renal arteries* are derived from three sources, the

phrenic artery, the aorta, and the renal artery. Their branches pass along in the trabeculæ and then converge to form a capillary plexus in the medullary substance, whence the capillary veins empty into the *supra-renal veins.* On the right side the latter joins the inferior vena cava, and on the left the left renal vein. The *lymphatic vessels* are numerous and pass to the lumbar lymphatic glands. The *nerves* are derived chiefly from the renal and solar plexuses. A few have been followed from the phrenic ganglion. The supra-renal bodies have no excretory ducts. Their function is unknown, but they are supposed to bear some important relation to the abdominal sympathetic system, owing to the ganglia which are found in connection with the nerve-filaments.

The deep structures on the posterior wall of the abdomen are the crura and ligamenta arcuata of the diaphragm (described on page 321, Vol. I.), the psoas, iliacus, and quadratus lumborum muscles on each side, the abdominal aorta, the inferior vena cava, the abdominal sympathetic nerves, the lumbar plexus of spinal nerves, the abdominal lymphatics, and the receptaculum chyli (Plates 62 and 63).

The *psoas magnus muscle* (Plate 62, No. 11) is the large fusiform fleshy mass situated at the side of the lumbar vertebræ, from the transverse processes of which it arises, as well as from the lateral borders of the bodies of the last dorsal and upper four lumbar vertebræ. In front of the vertebræ there are tendinous arches which stretch over the lumbar arteries, and from these some of the fibres also arise. The muscle descends vertically to the brim of the true pelvis, where it becomes tendinous and is with difficulty separable from the iliacus, with which it passes to be inserted into the posterior part of the lesser trochanter of the femur (page 230). The *psoas parvus muscle,* when it is present, arises from the bodies of the last dorsal and first lumbar vertebræ and the intervening fibro-cartilage, and descends in front and to the inner side of the psoas magnus muscle. Its tendon is very long and flat, and spreads out to be inserted into the linea ilio-pectinea (page 109) and the iliac fascia. This muscle is found in man only about once in eight or ten bodies: it is always remarkably developed in leaping

animals, such as the kangaroo. The *iliacus muscle* (Plate 87, No. 1) is fan-shaped, and arises chiefly from the inner lip of the crest of the ilium and the adjacent part of the iliac fossa, as far forward as the anterior spinous processes, and by a few fascicles from the ilio-lumbar ligament and the ala of the sacrum. The fleshy bundles descend and converge to form a strong tendon, which blends with the tendon of the psoas muscle and is inserted into the lesser trochanter of the femur, especially into its anterior roughened surface. The iliacus and psoas muscles are often considered as parts of one muscle, the *ilio-psoas*. The common tendon passes beneath the crural arch between the anterior inferior spinous process and the ilio-pubic eminence, directly over the capsule of the hip-joint (page 232). The iliacus is supplied by several small branches of the anterior crural nerve, and the psoas by branches from the lumbar plexus. Their combined action serves to flex the hip-joint and to rotate the thigh outward. In the latter effort the base of support of the body is widened so that it assists in maintaining the erect position. The outward rotation of the thigh by these muscles frequently occasions displacement in fractures of the upper part of the femur.

The fascia covering the psoas muscle is thin above, where it is attached to the ligamentum arcuatum internum and to the lumbar fascia, and below it blends with the fascia over the iliacus muscle. It is much thicker where it is attached to the iliac crest, to the brim of the pelvis, and to Poupart's ligament, except where it forms the posterior sheath of the femoral vessels and is prolonged to the insertion of the ilio-psoas tendon and thence to the fascia lata. Beneath the *ilio-psoas fascia* there is another distinct fascia, the *extra-peritoneal fascia*, which lines the lateral and posterior walls of the abdomen. This has been described in connection with the transversalis muscle (page 13). Above it is continuous with the infra-diaphragmatic fascia, and below it is attached to the iliac crest and to the whole of Poupart's ligament except in relation to the femoral vessels, where it passes into the thigh to form the anterior layer of their sheath. The arrangement of these fasciæ is of great importance, as it influences the direction of abscesses occurring in this

region. It will be understood from the above that an abscess beneath the extra-peritoneal fascia will be so enclosed that it will either point *above* the iliac crest or Poupart's ligament, or find its way along the inguinal tract. An abscess, on the other hand, occurring within the ilio-psoas fascia usually points at the outer side of the femoral vessels, in the upper part of the thigh. A psoas abscess is ordinarily the result of spinal caries (as in Pott's disease), and the psoas muscle serves as a guide for the pus to find its way to the groin *below* Poupart's ligament, just outside of the femoral vessels.

The *quadratus lumborum muscle* ascends obliquely from the crest of the ilium to the last rib at the sides of the lumbar vertebræ and externally to the psoas muscle (Plate 63, No. 11). There are two sets of fibres, one set arising from the ilio-lumbar ligament and the adjacent part of the posterior surface of the iliac crest above the gluteal line and passing to the lower border of the last rib and the transverse processes of the upper four lumbar vertebræ, and the other set arising from the iliac crest just behind the others and passing to the transverse processes of the upper three lumbar vertebræ. This muscle is covered by the extra-peritoneal fascia. It is supplied by the lumbar plexus of nerves. The crossed direction of the fibres, and its action in steadying the spine if acting from below, or the last rib if acting from above, have led to its being considered as analogous to the scaleni muscles in the neck (page 220, Vol. I.). The aponeurotic origin of the transversalis muscle separates the quadratus from the erector spinæ muscles. It should be remembered that the kidney lies on the anterior surface of the quadratus muscle, and that the outer border serves as a guide in the operation of nephrectomy, etc. (Plate 84, Fig. 2).

The abdominal aorta (Plate 62) begins at the twelfth dorsal vertebra and extends to the intervertebral disk of fibro-cartilage between the fourth and fifth lumbar vertebræ. It is fifteen centimetres, or six inches, in length, and twenty-one millimetres, or a little less than an inch, in diameter at its beginning. It descends a little to the left of the middle line on the bodies of the vertebræ, and gradually diminishes in diameter, being seventeen millimetres, or about three-fourths of an inch, at its

bifurcation into the common iliac arteries. It follows the convexity of the lumbar portion of the spine, and its greatest curve is on a level with the third lumbar vertebra. It can be here felt through the abdominal parietes by pressing a little above and to the left of the umbilicus, which is the proper point for the application of the abdominal tourniquet. The artery has in front of it the pancreas, the duodenum (Plate 61), the coat of the mesentery (Plate 59), and the renal vein. To the right is the inferior vena cava, with the right crus of the diaphragm which separates them above (Plate 62). To the left is the left crus of the diaphragm and the sympathetic gangliated nerve-cord. Behind it is the receptaculum chyli (Plate 63). The branches of the abdominal aorta are numerous, the largest being given off near together at its commencement. Their respective order is as follows. The *phrenic arteries* arise either separately or by a common trunk immediately below the aortic opening of the diaphragm (page 322, Vol. I.). Not unfrequently the left phrenic arises from the gastric artery. The right phrenic artery passes behind the inferior vena cava to the right leaflet of the diaphragm, and the left passes between the aortic and œsophageal openings of the diaphragm. They both give off external and internal branches, and branches to the supra-renal capsules (page 67). The right furnishes a twig to the inferior vena cava, and the left a twig to the œsophagus. They also supply small arteries to the capsules of the liver and of the spleen. The phrenic arteries inosculate with each other and with the six lower intercostal and internal mammary arteries. The *right phrenic vein* terminates in the inferior vena cava, the *left phrenic vein* in the corresponding renal vein or in the vena cava.

The *cœliac axis* is a short branch extending forward eleven millimetres, or about half an inch, between the crura of the diaphragm and just above the pancreas (Plate 61, No. 21). It divides into three important branches, the hepatic, gastric, and splenic arteries. These are described respectively on pages 54, 23, and 60. The *superior mesenteric artery* arises from the front of the aorta behind the pancreas (Plate 61) and crosses the transverse portion of the duodenum. The artery enters the mesentery and takes a curved direction with its con-

vexity to the left, giving off numerous branches to the intestinal canal (page 21). Upon either side of the aorta, opposite the superior mesenteric artery, arise the two *supra-renal arteries.* They pass to the under surface of the supra-renal capsules and anastomose with the supra-renal arteries from the phrenic and renal arteries. The *renal arteries* arise at right angles from the aorta just below the superior mesenteric. They are described on page 63. The next branches from the aorta are the *spermatic arteries.* They are very slender vessels, and arise below the renal arteries. Sometimes the left spermatic is given off from the corresponding renal artery (Plate 62, No. 25). They are distributed to the testes in the male (page 149) and to the ovaries in the female (page 125). They pass downward over the psoas muscles beneath the ureters and over the genito-crural nerves until they meet the vasa deferentia at the spermatic cords. In the female the ovarian arteries after entering the pelvis pass between the layers of the broad ligament of the uterus. The *right spermatic vein* empties into the inferior vena cava, and the *left* into the left renal vein (Plate 62, No. 24). The *inferior mesenteric artery* arises from the front of the aorta from three to five centimetres, or from one and a quarter to two inches, above the bifurcation of the common iliac arteries. It passes downward in the layers of the mesocolon and distributes its branches to the large intestine (page 21).

Besides the above branches, there are four pairs of *lumbar arteries* given off laterally from the posterior surface of the abdominal aorta. They correspond to the intercostal arteries. The right lumbar arteries pass beneath the inferior vena cava. On both sides they pass beneath the tendinous arches of the psoas muscles and divide into abdominal and dorsal branches. The *abdominal branches* supply the muscles and skin of the lateral walls of the abdomen and anastomose with the epigastric, lower intercostal, ilio-lumbar, and circumflex arteries. The *dorsal branches* pass backward between the transverse processes of the lumbar vertebræ, sending branches to the muscles and skin of the back in this region, and also furnishing *spinal branches,* which enter the intervertebral foramina and are distributed like the similar branches

of the intercostal arteries. The *lumbar veins* empty into the inferior vena cava.

The *sacra media artery* leaves the posterior surface of the aorta immediately above the bifurcation. It is the diminutive continuation of the aorta, and descends beneath the left common iliac vein over the middle of the sacrum (Plate 68, No. 45) and along the middle of the coccyx, where it is called the *coccygeal* or *caudal artery*, and ends in the **coccygeal glomerulus,** or **gland of Luschka.** This is a little body, about the size and shape of a pea, situated at the tip of the coccyx, between the levatores ani and sphincter ani muscles. It is composed of a plexus of capillary arteries surrounded by several layers of granular cells and invested by connective tissue, and resembles the *intercarotic body* (Vol. I., page 203). The sacra media artery gives off small twigs, which anastomose with the lateral sacral and rectal arteries. The *sacra media vein* empties into the left common iliac vein.

The common iliac arteries are the last pair of branches arising from the end of the aorta (Plate 62). They diverge from each other at an angle of sixty degrees in the male and of sixty-eight degrees in the female. Their origin is commonly called the *bifurcation of the aorta.* The *right* common iliac artery measures five centimetres, or about two inches, in length, and its diameter is eleven millimetres, or half an inch; the *left* common iliac artery measures about four centimetres, or one and three-quarter inches, in length, and its diameter is usually a little less than that of the right. There is, however, much variance in the length of the common iliac arteries, so that these measurements are merely approximative. They are frequently found to be only three-fourths of an inch in length. The *right* artery passes to the right sacro-iliac joint, and is crossed at its termination by the right ureter. It is directly over the corresponding iliac vein, and at its origin crosses the termination of the left iliac vein in the inferior vena cava. The *left* artery passes under the superior rectal artery and the left ureter, and at its termination is over its own vein. There are minute *peritoneal* and *subperitoneal branches* given off by the common iliac arteries, which establish important capillary extra-peritoneal anastomoses with similar

PLATE 62.

The viscera and intestines are removed, with the peritoneum, deep fascia, and fat, to show the relations of the kidneys and great vessels and nerves on the posterior wall of the abdomen.

1. The right leaflet of the diaphragm, with phrenic vessels and nerves.
2. The right supra-renal body, in a bed of fat, surmounting the kidney.
3. The right renal vein.
4. The right renal artery.
5. The junction of the right spermatic vein with the inferior vena cava.
6. The right kidney.
7. The ilio-hypogastric and ilio-inguinal nerves crossing the lumbar fascia.
8. The inferior vena cava.
9. The ilio-lumbar artery, and the external cutaneous nerve of the thigh.
10. The right ureter.
11. The right psoas muscle.
12. The right external iliac artery.
13. The right anterior crural nerve.
14. The deep circumflex iliac artery.
15. The right spermatic artery.
16. The right spermatic vein and genito-crural nerve.
17. The bladder (distended).
18. Vas deferens of the right side.
19. The central tendon of the diaphragm.
20. The œsophageal opening.
21. The left leaflet of the diaphragm.
22. The crura of the diaphragm.
23. A renal artery (entering the hilum of the left kidney, above the vein).
24. The left spermatic vein at its junction with the left renal vein.
25. Another renal artery (entering the hilum below the vein), and in this instance giving origin to the left spermatic artery.
26. The superior mesenteric artery, turned aside.
27. The left ilio-hypogastric nerve.
28. The abdominal aorta in relation to the third lumbar vertebra—before its bifurcation.
29. The superior hæmorrhoidal artery.
30. The left ilio-inguinal nerve.
31. The left ureter.
32. The left iliacus muscle.
33. The left common iliac vein.
34. The middle sacral artery.
35. The left external cutaneous nerve.
36. The rectum (tied).
37. The left anterior crural nerve.
38. The left genito-crural nerve.
39. The left external iliac artery.
40. The left external iliac vein.
41. The left spermatic cord.

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twigs from the lumbar, phrenic, and renal arteries. The common iliac arteries respectively divide into the internal and external iliac arteries. The former descends into the pelvis, and is described on page 152.

The external iliac artery is the main blood-carrying vessel to the lower extremity. It is usually ten centimetres, or about four inches, in length, with a diameter of eight millimetres, or one-third of an inch. It passes along the brim of the pelvis and escapes beneath the femoral arch, where it becomes the femoral artery (page 255). It is at first on the inner side of the psoas muscle, and then in front of it (Plate 62, No. 12). The corresponding *iliac vein* is at its inner side, and both vessels are included in a sheath derived from the iliac fascia. The external iliac artery is *outside* of the peritoneum (as are also all the above branches of the aorta), and it is covered by a strong layer of subperitoneal areolar tissue (*Abernethy's fascia*). There are a number of lymphatic glands along the border of the external iliac vein, and these receive minute twigs from the external iliac artery; but the only branches of size and importance are the two which arise opposite each other from its lateral surfaces just as the artery passes beneath Poupart's ligament (Plate 76, Fig. 2). These are the deep circumflex iliac and deep epigastric arteries.

The *deep circumflex iliac artery* ascends to the anterior superior spinous process of the ilium, usually covered by a fold of the iliac fascia, and thence passes between the transversalis and internal oblique muscles along the crest of the ilium. It gives off superficial and deep branches which anastomose chiefly with the superficial circumflex, superficial gluteal, and ilio-lumbar arteries. *Venæ comites* accompany this vessel. The *deep epigastric artery* at first passes inward and then ascends toward the ensiform cartilage. At first it is behind Poupart's ligament at the inner side of the deep abdominal opening (Plate 69, Fig. 1, No. 3), and between the peritoneum and the extra-peritoneal fascia. As it ascends it pierces the sheath of the rectus muscle close to the semilunar fold of Douglas (page 31), and passes upward on the back of the muscle to anastomose above the umbilicus with the superior epigastric branch of the internal mammary artery (Plate 55, No. 21). The artery is also provided with

venæ comites. The branches of the epigastric artery are the *cremasteric*, which descends on the spermatic cord to supply the cremaster muscle (Plate 68, Fig. 2, No. 14), the *pubic*, which forms an anastomosing rete over the pubes with the pubic branch of the obturator artery and its fellow from the opposite side, and the *obturator*, which passes to the internal obturator muscle. Sometimes the latter becomes dilated and is the irregular origin of the obturator artery from the epigastric (Plate 76, Fig. 2, No. 5).

In the operation for ligation of the external iliac artery the thigh should be extended and everted, and a slightly-curved incision should be made parallel to and about four centimetres, or two finger-breadths, above the fold of the groin, commencing opposite the anterior superior iliac spine and stopping short of the middle of Poupart's ligament, so as to avoid the epigastric artery. The skin, superfical fascia, layers of muscles, and extra-peritoneal fascia forming the wall of the abdomen should be cut through upon a grooved director until the parietal layer of the peritoneum is reached, which in this location is indicated by the sub-serous tissue above mentioned. The peritoneum can be easily separated from the iliac fossa by gently pressing upon it with the pulps of the fingers, and the sheath of the vessel thus exposed. Care should be taken not to work too close to Poupart's ligament, on account of the relations of the spermatic vessels, the genito-crural nerve, and the circumflex iliac vein. The external iliac vein is always close to the inner side of the artery, except in very old individuals, in whom, owing to the tortuous condition of the artery, it may overlap the vein. The latter can, however, be made prominent by pressing over the cardiac end. Sometimes the lymphatic glands which are in close relation to the external iliac vein are found enlarged, thus adding to the confusion.

The *collateral circulation after ligation of the external iliac artery* would be maintained by the occluded branches drawing the blood from their anastomoses mainly between the deep epigastric artery and the internal mammary and its communications with its fellow from the opposite side and with the obturator, and between the circumflex iliac artery and the lumbar arteries and the iliac branch of the ilio-lumbar artery.

If it is desired to secure with a ligature either of the common iliac arteries, the same incision as above described for reaching the external iliac should be made, and prolonged upward two and one-half centimetres, or about an inch, as far as the tip of the last rib. It should be remembered that the common iliac arteries hold different relations to their corresponding veins upon the two sides (Plate 62), and, as their respective lengths are subject to variation (page 73), it is perhaps safest first to expose the external iliac artery, and then by following it to its origin the common iliac artery can be readily secured.

The inferior vena cava begins a little to the right of the intervertebral disk between the fourth and fifth lumbar vertebræ, and ascends to its proper opening in the diaphragm opposite the lower border of the ninth dorsal vertebra. Its course inclines gradually to the right of the middle line. At first it occupies a plane posterior to the aorta, but at its termination it is anterior to it and is separated from it by the right crus of the diaphragm. This great vein is subject to the pressure of the surrounding parts, and it probably never assumes during life the cylindrical shape occasioned by an artificial distention. Above it lies in a fissure on the under surface of the liver (page 52), which is often bridged over by a band of fibrous tissue or hepatic substance (Plate 64, Fig. 2, No. 19). It originates by the union of the two common iliac veins, and in its course receives the lumbar veins, the right spermatic vein, the two renal veins, the right middle supra-renal vein, the hepatic veins, and the two phrenic veins.

The abdominal sympathetic nerves consist of two series, the great splanchnic nerves and the lumbo-sacral chain of ganglia. The *great splanchnic nerves* (the origins of which occur within the thorax, and have been described on page 320, Vol. I., and are shown in Plates 36 and 37, Vol. I.), after passing through the openings in the diaphragm, descend, each crossing the adjoining crus of the diaphragm, so that the right nerve is behind the inferior vena cava and the left nerve is behind the pancreas. Their terminations unite in a large, irregularly-shaped cluster of ganglia, the whole mass being called the *semilunar ganglion.* Passing from right to left, from the several terminal ganglia

of the splanchnic nerves are thick nerve-branches which surround the cœliac axis of the aorta in an intricate mesh-work, forming the great *cœliac* or *solar plexus*. This also receives branches from the thoracic aortic plexus and from the *right* pneumogastric nerve. From the solar plexus nerve-branches proceed which form secondary plexuses over the coats of all the abdominal arteries and accompany them throughout their distributions to the viscera. The various plexuses thus formed are the *gastric*, the *hepatic*, the *splenic*, the *mesenteric*, the *phrenic*, the *supra-renal*, the *renal*, and the *spermatic*. They are severally referred to with the consideration of the parts to which they particularly belong. The *lumbo-sacral chain of ganglia* (Plate 63, Nos. 14 and 41) is the sympathetic nerve-cord which passes downward on the bodies of the lumbar and sacral vertebræ internally to the psoas muscle and to the sacral foramina. There are usually four oval, grayish-colored ganglia in the lumbar region, and over the sacrum three or four. These ganglia are all connected by whitish nerve-cords extending from one to the other, and they receive filaments from the corresponding spinal nerves. Toward the end of the sacrum the nerve-cords join, and there is very often found in front of the coccyx a small ganglion, which is called the *coccygeal ganglion*, or *ganglion impar*. Branches pass from the upper three lumbar ganglia to join with branches from the renal and solar plexuses in forming the *aortic plexus*. This is especially pronounced upon the left side, and contributes mainly to the *inferior mesenteric plexus* in relation to the large intestine below the splenic flexure of the colon. Below the bifurcation of the aorta there are numerous filaments from the aortic plexus and from the lower ganglia, which unite, forming the important *hypogastric plexus*, in front of the promontory of the sacrum. This plexus presides over the pelvic viscera, its filaments being intricately interwoven with the many branches of the internal iliac arteries, which they accompany throughout their distribution.

The lumbar plexus of spinal nerves (Plate 63) is formed by the union of the anterior branches of the four upper lumbar nerves, and is usually connected with the last dorsal nerve by a branch, the *dorsi-lumbar nerve*. The fifth lumbar nerve does not enter into the plexus,

but passes down to join the sacral plexus as the *lumbo-sacral cord.* The psoas muscle must be carefully removed to show the branches of the lumbar plexus as they pass directly through that muscle. There are five branches, which increase in size from above downward. The first lumbar nerve usually divides into the *ilio-hypogastric* and *ilio-inguinal nerves* (Plate 63, Nos. 9 and 10). They both emerge from the outer border of the psoas muscle, and, crossing the quadratus lumborum muscle, pass forward to the crest of the ilium, where they pierce the transversalis muscle and divide into their terminal branches (page 8). They are purely sensory nerves. The *genito-crural nerve* is formed by filaments from the first and second lumbar nerves, and, piercing the psoas muscle, descends along its anterior surface (Plate 62, No. 38) as far as the outer side of the external iliac artery, where it divides into its genital and crural branches. The former, the motor portion, in relation to the deep abdominal opening, passes into the substance of the spermatic cord to supply the cremaster muscle (page 13), while the latter (the sensory portion) pierces the fascia beneath Poupart's ligament, in relation to the sheath of the femoral vessels (Plate 68, Fig. 1, No. 13), and is distributed to the skin of the thigh, very often uniting with the middle cutaneous branch of the anterior crural nerve. The *external cutaneous nerve of the thigh* is formed usually by filaments from the second and third lumbar nerves. It passes obliquely over the psoas and iliacus muscles to the anterior superior spine of the ilium, and comes forward over the attachment of the sartorius muscle to supply the skin on the outer side of the thigh. The *anterior crural nerve* is the largest of all the branches, and is formed by the third and fourth lumbar nerves, joined by a small branch from the second nerve. It descends in the interspace between the psoas and iliacus muscles, both of which it supplies, and then passes under Poupart's ligament at the outer side of the femoral artery. It is distributed to the extensor muscles of the knee, to the sartorius and pectineus muscles, and to the skin of the thigh (page 244) and leg (page 302). The *obturator nerve* is formed also by the third and fourth lumbar nerves, and after piercing the psoas muscle it runs along the brim of the pelvis above the obturator artery

and vein to the obturator foramen (Plate 76, Fig. 1, No. 17). Very often there is an *accessory obturator nerve*, which is derived either from the obturator nerve itself or from the third and fourth lumbar nerves. It accompanies the main nerve and supplies the hip-joint (page 235).

The abdominal lymphatic vessels may be said in a general way to form plexuses in relation to the principal arteries and veins. They are continuous upward from the common iliac and sacral lymphatic plexuses to a cluster of lymphatic glands about the abdominal aorta, which are united by cross-branches, forming the *median aortic lymphatic plexus*. These are joined by the lymphatic vessels on the left side, which come from the descending portion and sigmoid flexure of the colon, and on both sides receive, in the male, the lymphatic vessels from the testes and spermatic cords, or, in the female, the ovarian and tubal lymphatics. The supra-renal and renal lymphatic vessels convey their lymph to several lymphatic glands above the renal artery on each side. There are also groups of lymphatic glands in relation to the inner borders of the psoas muscles, which receive the afferent lymph-vessels between the psoas muscles and the lumbar vertebræ around each lumbar artery. The efferent lymph-vessels from these sources all unite in the aortic plexus, and at its upper part on each side of the second lumbar vertebra blend into a single trunk, called respectively the *right* and *left truncus lymphaticus lumbalis*. They are both placed between the aorta and the vena cava, and often cross each other before they unite behind the right renal artery in the *receptaculum chyli*. The lymphatic vessels arising from the intestinal canal are called *lacteals* (page 43). Their efferent vessels mostly join in forming a single trunk, called the *truncus lymphaticus intestinalis*. The lymphatic vessels from the stomach (page 39), from the spleen (page 60), from the pancreas (page 59), and from the greater part of the liver and gall-bladder (page 55) converge to the *cœliac lymphatic glands*, of which there are about twenty, situated in relation to the cœliac axis and the upper part of the aorta. Their efferent vessels commonly join the mesenteric lymphatics in forming the main trunk.

The cœliac and lumbar lymphatic glands have intercommunicating

branches. The main lymphatic trunks formed as above described empty into the commencement of the *thoracic duct* (page 318, Vol. I.), which is opposite the second lumbar vertebra, behind and between the aorta and the right crus of the diaphragm. It is here called the **receptaculum chyli**, or *reservoir of Pecquet* (Plate 63, No. 32). It is a very thin-walled, tortuous sac, somewhat fusiform, about thirty-five millimetres, or an inch and a half, in length, and eight millimetres, or one-third of an inch, in breadth. There are few valves in the main lymphatic trunks, and none in the receptaculum.

THE INGUINAL REGION, OR THE GROIN.

Much of the anatomy of this region is inseparable from that of the abdomen, and has, therefore, been already treated; but as hernia, or the protrusion of a portion of the intestine, is especially liable to occur through certain weak places above and below Poupart's ligament, an accurate understanding of the relations of the structures in these localities is very necessary to the surgeon.

Ordinarily, when unaffected by injury, disease, or malformation, the lower portion of the anterior wall of the abdomen is capable of retaining the viscera within the abdominal cavity. The arrangement and interlacing of the fasciæ in this region constitute one of the most beautiful evidences of the adaptation of the structure to the fulfilment of its function in the anatomy of man. In the erect position the fasciæ above Poupart's ligament are rendered tense and unyielding, so that not only is support afforded to the contained viscera, but also the naturally weak places of the groin are effectually closed. It is only when the parts are in a state of relaxation, or where the muscles are, as it were, taken unawares, that a portion of the bowel can insinuate itself into any of the weak places and be protruded under the influence of pressure during the exercise of effort. While it may be asserted that every hernia is due to some congenital condition which predisposes to it, and that the effort which occasions the affection would not so operate except for the existence of some such condition, it should not be overlooked that the

PLATE 63.

The under surface of the diaphragm, the posterior wall of the abdomen, and the inlet of the pelvis, as seen upon removal of the viscera and reflection of the deep fascia; also the lumbar and sacral plexuses of nerves, the sympathetic nerves, and the receptaculum chyli.

1. The central tendon of the diaphragm.
2. The opening in the diaphragm for the inferior or ascending vena cava.
3. The right phrenic artery and nerves.
4. The right leaflet of the diaphragm.
5. The right crus of the diaphragm.
6. The right ligamentum arcuatum externum.
7. The right twelfth dorsal nerve.
8. The first lumbar ganglion of the right sympathetic nerve.
9. The right ilio-hypogastric nerve.
10. The right ilio-inguinal nerve.
11. The right quadratus lumborum muscle.
12. The third right lumbar nerve.
13. The right external cutaneous nerve.
14. The third right lumbar ganglion of the sympathetic nerve.
15. The right ilio-lumbar artery.
16. The fourth right lumbar nerve.
17. The right iliac muscle.
18. The right common iliac vein.
19. The right sacro-lumbar cord.
20. The right obturator nerve.
21. The first right sacral nerve.
22. The second right sacral nerve.
23. The right anterior crural nerve.
24. The right genito-crural nerve.
25. The third right sacral nerve.
26. The cut ends of the right external iliac artery and vein.
27. The œsophageal opening of the diaphragm.
28. The left phrenic artery and nerve.
29. The aorta, just above the cœliac axis, where it passes through the diaphragm.
30. The left ligamentum arcuatum externum.
31. The left ligamentum arcuatum internum.
32. The receptaculum chyli.
33. The vena azygos major.
34. The left ilio-hypogastric nerve.
35. The left twelfth dorsal nerve.
36. The left ilio-inguinal nerve.
37. The left psoas magnus muscle.
38. The lowest portion of the inferior vena cava.
39. The left ilio-lumbar artery.
40. The lowest part of the abdominal aorta.
41. The left fourth ganglion of the sympathetic nerve
42. The left iliacus muscle.
43. The left external cutaneous nerve.
44. The left common iliac artery.
45. The sacra media artery.
46. The left anterior crural nerve.
47. The left sacral plexus of nerves.
48. The brim of the pelvis.

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[illegible]

habitual positions assumed in many vocations necessarily subject the groin to strain, under which the parts may gradually yield. The most common form of inguinal hernia is that which follows the course of the spermatic cord.

Before examining the various tissues in the neighborhood of the canal or tract in which the cord is placed, as exposed by consecutive dissections (Plates 68 and 69), it is well to take a superficial view and to notice the *landmarks* (Vol. I., Plates 27 and 28). Of these, the anterior superior spinous process of the ilium is always easily recognizable. The spine of the pubis is about on a line with the top of the great trochanter of the femur,—a fact which is important, as the spine is often obscured by fat. It can, however, usually be detected in the male by pushing the finger upward under cover of the loose scrotal tissues, with the thigh flexed. In the female, when the thigh is abducted, the tendon of attachment of the adductor longus muscle leads directly to it. The *skin* is very loosely attached over the groin by the superficial fascia to Poupart's ligament, which is usually indicated by a slight furrow, and can be felt when the thigh is abducted and fully extended. It should be remembered that the direction which Poupart's ligament takes is not straight, but curved, with the concavity toward the abdomen. The superficial abdominal opening can be readily felt by pushing the finger up in front of the cord, with the thigh flexed. The deep abdominal opening is placed two centimetres, or about a finger-breadth, above the middle of Poupart's ligament.

Upon removal of the skin, the *superficial fascia* will be found to consist of two layers, between which are the superficial vessels and nerves and the inguinal lymphatic glands (Plate 68, Fig. 1). The outer layer of the fascia varies in thickness, depending upon the amount of fat contained in its meshes. Below Poupart's ligament it is continuous with the superficial fascia of the thigh, but as it passes over the spermatic cord it is destitute of fat, is of a reddish-brown color, and blends with the deep layer of the superficial fascia to form the dartos tissue of the scrotum, whence it passes backward to be continuous with the superficial fascia of the perineum (page 161). The vessels and nerves are in close

relation to the deep layer of the superficial fascia. The *arteries* all arise from the common femoral artery and pierce the saphenous opening of the fascia lata (page 95). The superficial epigastric artery passes upward over Poupart's ligament toward the sheath of the rectus muscle. It supplies the skin and anastomoses with the pubic and deep epigastric arteries. The *superficial circumflex iliac artery* passes outward along the lower border of Poupart's ligament. The *superficial pubic artery* arches across the spermatic cord (Plate 54, No. 11), and is always in the way of the incision made in inguinal herniotomy. The *veins* which correspond to these arteries are comparatively large, especially the epigastric, which often communicates with the lateral abdominal vein (page 6). The *nerves* are the *ilio-hypogastric* and the *ilio-inguinal.* They come through the aponeurosis of the external oblique muscle at the outer side of the superficial abdominal opening (Plate 68, Fig. 1, No. 4). The *lymphatic vessels* from the scrotum, the penis, and the perineal and gluteal regions follow the course of the vessels and terminate in a small cluster of superficial glands about Poupart's ligament, one being just above it and in relation to the epigastric artery, called the *epigastric lymphatic gland* (Plate 68, Fig. 1, No. 3).

When the two layers of the superficial fascia are removed, the thin silvery-white aponeurosis of the *external oblique muscle* (page 9) is brought into view, with the spermatic cord in the male, or the round ligament of the uterus in the female, issuing from between the lowest fibres of the aponeurosis as they approach the pubes. The opening through which these structures pass is the **superficial abdominal opening.** It is not a ring, as commonly called, but a very oblique triangular slit formed by the separation of the lowest part of the tendon of the external oblique muscle into two bands of fibres. The upper band is the thinnest, and passes to the symphysis of the pubes, where it interlaces with the corresponding band of fibres from the opposite muscle. The lower band, which forms the lower margin of the aponeurosis, is broad as well as strong, and passes from the anterior superior spine of the ilium to be inserted into the spine of the pubis. It constitutes **Poupart's ligament,** or the femoral arch (page 9), and, as the fascia lata

is attached to its lower border, it is influenced by the position of the thigh, being rendered tense when the thigh is extended and relaxed when it is flexed. Its direction is always that of a gentle curve, with the concavity upward, as above stated. If examined from within, the pubic portion of Poupart's ligament will be found to be reflected along the linea ilio-pectinea of the pelvis as *Gimbernat's ligament* (page 96). Because of this reflection the lower border of the ligament of Poupart is turned backward in a shelf-like manner, thus affording attachment for the subjacent abdominal muscles (page 11), and, what is more important, for the support of the spermatic cord. The reflection upon the ilio-pectineal line is strengthened by a triangular band of fibres extending upward to the linea alba behind the inner column of the superficial opening. The structure of the round ligament (page 115) becomes lost at the superficial abdominal opening in the tissues of the mons pubis. Owing to its small size, the inguinal canal and the external opening itself are comparatively less developed in the female, who is consequently rarely affected with inguinal hernia. In the male the superficial opening usually measures three centimetres, or about an inch and a quarter, in length, but it varies considerably, depending upon the degree with which its sides are applied to the spermatic cord. The margins of the opening are called the *pillars* or *columns*, the outer column being formed by Poupart's ligament and the inner column by the band of the aponeurosis attached at the pubic symphysis. Between the columns there is a delicate fascia of condensed connective tissue, the *intercolumnar fascia* (Plate 68, Fig. 1, No. 2), and as the cord in passing through the opening rests upon the outer column this fascia is prolonged over it and becomes the *external spermatic fascia.* The lower fibres of the *internal oblique muscle* (page 12) usually appear very thin and of a pale color as they arise from the upper surface of the inner border of Poupart's ligament externally to the spermatic cord, across which they curve downward, and, becoming tendinous, blend with the tendon of the transversalis muscle at the crest of the pubes. The spermatic cord usually receives an investment of fascia from the contiguous border of the internal oblique muscle, consisting of alternating

loops of loose cellular tissue and muscle-fibres, called the *cremaster* (Plate 68, Fig. 2, No. 14). This muscular covering is usually more pronounced at the outer part of the cord, and is always more easily distinguished than the other coverings. In some bodies it is difficult to trace any connection between the cremaster, even when it is well developed, and the lower border of the internal oblique, the former appearing to be festooned across from Poupart's ligament externally to the cord, to the pectineal line of the pubes. In several cases of undescended testicle some looped fibres corresponding to the cremaster have been found in the scrotum, so that the supposition that it is a survival of the *gubernaculum testis* (page 89) would seem to be confirmed.

Ordinarily the *transversalis muscle* (page 13) does not descend so low as the internal oblique, so that upon the removal of the latter the cord appears surrounded with the underlying *extra-peritoneal fascia.* The fibres of the transversalis muscle become tendinous and blend with those of the internal oblique, forming the *conjoined tendon* (Plate 68, Fig. 4, No. 9), which is attached to the crest of the pubes in front of the rectus muscle. This arrangement serves to strengthen the abdominal wall where it is weakened by the presence of the superficial opening. There are many differences in the disposition of the lower borders of the internal oblique and transversalis muscles, which may be revealed by careful dissections of this region in different bodies. Sometimes the fleshy parts of the two muscles blend as well as their tendons. Sometimes the spermatic cord passes through the muscular fibres of one or both of these muscles, so that it is surrounded with muscular fibres which may possibly exert the influence of a sphincter upon the deep abdominal opening. There is always a small tendinous reflection from the conjoined tendon behind the spermatic cord. These facts are worthy of consideration, as they doubtless account for the position and character of the constrictions which occur and often produce strangulation.

The *extra-peritoneal fascia,* usually called the transversalis fascia from its intimate association with the transversalis muscle, is a distinct membrane lining the general wall of the abdomen (page 17). It becomes quite thick and strong in the groin, where it is attached to the whole

of the posterior border of Poupart's ligament except in relation to the femoral vessels, over which it is prolonged into the thigh as the anterior layer of their sheath (page 97). It therefore fills up the interspace occurring from the deficiency of the transversalis muscle above Poupart's ligament. At a point two centimetres, or about a finger-breadth, above the centre of the latter, the fascia is prolonged above the spermatic cord in a funnel-shaped expansion. This is called the *infundibuliform fascia,* or *internal spermatic fascia.* The above point corresponds to the position of the **deep abdominal opening,** which does not actually exist unless made artificially by the separation of the fascia from the cord (page 16). The *inguinal tract*—or *inguinal canal,* as it is commonly called—extends between the deep and superficial openings. It is from four to five centimetres, or about an inch and a half to two inches, in length in the adult, and is placed parallel with Poupart's ligament. It is occupied by the spermatic cord. It is formed in front by the aponeurosis of the external oblique muscle, above by the lower margins of the internal oblique and transversalis muscles, behind by the extra-peritoneal fascia, and below by Poupart's ligament. The latter separates it also from the sheath of the femoral vessels and from the space called the femoral canal (page 97) (Plate 76, Fig. 2, No. 8). The spermatic cord consists of the arteries, veins, lymphatic vessels, nerves, and the excretory duct, or vas deferens, of the testicle, held together by a quantity of loose areolar tissue (page 145). Beneath the extra-peritoneal fascia, extending across the lower part of the abdomen, is the *subperitoneal areolar tissue,* which contains more or less fat in its meshes and is usually well developed about the position of the deep abdominal opening. As it is generally expanded over the spermatic cord on the occasion of a hernia, it is called the *fascia propria.* The *parietal peritoneum* in relation to the groin should be examined on the inner side, when it will be noticed that the delicate membrane bulges slightly forward upon either side of the cord resulting from the obliterated hypogastric artery, thus forming the *outer* and *inner inguinal pouches* (page 19). The outer pouch is directly behind the superficial opening, and the inner pouch behind the deep opening.

The position of the *deep epigastric artery* is one of the most important points in the anatomy of the inguinal region, in consequence of its close relation to the various forms of hernia. The artery arises from the external iliac (page 75) just before that artery issues beneath Poupart's ligament to become the femoral, and passes obliquely upward between the extra-peritoneal fascia and the peritoneum to the sheath of the rectus muscle (page 15). The artery can be felt through the extra-peritoneal fascia ascending behind the commencement of the spermatic cord close to the inner border of the deep abdominal opening (Plate 69, Fig. 1, No. 3). Its course is directly over that of the obliterated hypogastric artery, above referred to, when the bladder is distended. It is usually accompanied by two veins.

From the above it will be understood that the spermatic cord while it is within the inguinal canal is invested by the infundibuliform fascia and the cremaster: after leaving the external opening it receives the intercolumnar fascia, the two layers of the superficial fascia, which here blend to form the dartos, and the skin. The manner in which these coverings are obtained by the cord can be best explained by referring briefly to the course of the descent of the testicle and to the formation of the cord which is coincident with it.

The testicles in the fœtus are first formed below and in front of the kidneys, in the back wall of the abdomen, behind the peritoneum. About the fifth month they leave their original position, carrying along the peritoneum which covers them in front and at the sides, and gradually descend to the groins, which they reach about the seventh month. The aggregation of the developing constituents of the spermatic cord occurs at the same time.

The *spermatic artery* naturally elongates with the downward progress of the testicle, and is accompanied by the *spermatic vein* issuing from it. The *spermatic duct*, or *vas deferens*, as it passes out of the back part of the testicle to go to the seminal vesicle (page 150) at the base of the bladder, becomes associated with the vessels, together with the nerves and lymphatic vessels, proper to the organ, at the deep abdominal opening, and they are all enveloped in a loose areolar tissue. The cord thus

constituted, therefore, commences at the deep abdominal opening, and as the testicle proceeds through the inguinal canal it becomes invested with the various fasciæ. These are probably not detached from their respective sources by the dragging of the testicle through them, but rather, it would seem, are specially developed and prolonged—just as the outer layer of the peritoneal lining of the abdominal wall is now known to be prolonged—through the primitive inguinal canal into the scrotum before the testicle reaches it. This parietal layer of the peritoneum thus forms the outer layer of the tunica vaginalis in the male and of the canal of Nuck in the female, so that, in the male, when the testicle arrives at the position of the deep abdominal opening it finds a peritoneal pouch or process already prepared for it. Extending from the bottom of the fœtal testis is a fibrous band passing before it into the peritoneal pouch, through the inguinal canal, and into the scrotum. This fibrous band is called the *gubernaculum*, and there has been much speculation regarding its probable function. Owing to the occasional presence of muscular fibres, the fanciful theory has been advanced that the gubernaculum serves to draw the testicle first down to the deep opening, then along the canal, and finally through the superficial opening into the scrotum. There is nothing to prove this, however, and it is probable that the little fold proceeding from the bottom of the testicle to the bottom of the peritoneal pouch above described serves as a guide for its descent. The latter explanation is borne out by the facts that the pelvis is so small and narrow at this time that the position of the deep opening is practically just behind the superficial opening, and that the length of the fœtal inguinal canal amounts only to the thickness of the structures composing the abdominal wall, so that the course of the descent of the testicle from where it was originally formed below the kidney to its final normal position in the scrotum is more direct than indirect.

As the pelvis gradually broadens so as to accommodate the viscera, there must be an influence exerted upon the fasciæ which are attached to it, and also upon any structure, such as the cord, passing through them. The subsequent changes which take place both in the indirect course of the inguinal canal and in the various forms of congenital

PLATE 64.

Figure 1.

The anterior and upper surfaces of the liver.

1. The inferior vena cava.
2. The coronary ligament.
3. The right lateral ligament.
4. The right lobe.
5. The fundus of the gall-bladder.
6. The left lateral ligament.
7. The left lobe.
8. The broad or suspensory ligament.
9. The round ligament.

Figure 2.

The posterior and under surfaces of the liver.

1. The inferior vena cava.
2. Hepatic veins.
3. The coronary ligament.
4. The obliterated ductus venosus.
5. The left lateral ligament.
6. The fissure of the ductus venosus.
7. The lobus Spigelii.
8. The longitudinal fissure.
9. The left lobe.
10. The transverse or portal fissure.
11. The hepatic artery.
12. The common hepatic duct.
13. The fissure of the umbilical vein.
14. A branch of the cystic artery.
15. The obliterated umbilical vein.
16. The lobus quadratus.
17. The gall-bladder (distended).
18. The right lateral ligament.
19. The *pons hepatis*, over the inferior vena cava.
20. The fissure of the vena cava.
21. The inferior vena cava.
22. Hepatic vein.
23. The lobus caudatus.
24. The right lobe.
25. The portal vein.
26. The fissure of the gall-bladder.

Figure 3.

The right kidney, seen from behind.

1. The superior border.
2. The right renal vein.
3. The right renal artery.
4. The right ureter.
5. The inferior border.
6. The hilum.
7. The pelvis.

Figure 4.

Longitudinal section of the right kidney, to show the relations of the branches of the renal artery and renal vein.

1. The superior border.
2. The inferior border.
3. The right renal artery.
4. The right renal vein.
5. The ureter.

Figure 5.

Longitudinal section of the right kidney. The vessels are removed to show the structure of the organ.

1. The cortical substance.
2. The superior infundibulum.
3. Calyx.
4. Papillæ.
5. Column of Bertini.
6. The middle infundibulum.
7. Pyramid of Malpighi.
8. The inferior infundibulum.
9. The cortical substance.
10. Pyramid of Malpighi.
11. Calyx.
12. The pelvis.
13. The ureter.
14. Calyx.
15. Papilla.

3

4

Fig 3

Fig 4

Fig 5

3

4

3

George Mc Clellan M.D.

defect which are commonly met with may thus be accounted for. It will be understood from the above that the testicle when it has finally reached the scrotum has both the proper peritoneal covering (*mesorchium*) which it has brought down with it and the layer of peritoneum which has preceded it,—in other words, a double layer, which eventually becomes the *tunica vaginalis testis* (page 145). This is completed, usually about the time of birth, by the gradual adhesion and closure of both of the peritoneal layers at the deep abdominal opening or somewhere along the spermatic cord above the testicle, so that there is normally no connection between the cavity of the vaginal tunic and the cavity of the abdomen. In many dissections, however, the author has found that a minute canal can be demonstrated between these cavities, showing that the complete obliteration of the peritoneal covering in relation to the cord is not always effected, even when it appears to be so. Upon the different conditions of the vaginal tunic depend the different varieties of hernia which follow the course of the spermatic cord.

These herniæ consist of a protrusion of the intestine, or of omentum, or of both, and are called *indirect* or *oblique inguinal*, from their course in the adult. They have the following characteristics. A *scrotal hernia* is a protrusion, covered by a layer of the parietal peritoneum (called its *sac*), through the inguinal canal in front of the cord. During its passage through the latter it receives the coverings peculiar to the cord, and after issuing from the superficial opening it passes down into the scrotum, being arrested only by the attachment of these coverings to the tunica vaginalis, which is closed above the testicle. Such a hernia, therefore, possesses the following coverings from within outward: the proper peritoneal sac, the sub-serous tissue, the infundibuliform fascia, the cremaster, the intercolumnar fascia, the dartos, and the skin. When the hernia passes all the way into the scrotum, it is commonly said to be *complete;* when it is arrested within the inguinal canal, it is *incomplete.* The latter is also known as *bubonocele.* A *congenital hernia* is a protrusion, without any peritoneal sac of its own, into the vaginal tunic which has not become separated from the general peritoneal cavity of the abdomen. Such a hernia may occur at any age. When the vaginal

process of the peritoneum is occluded only at the deep opening and there is a continuation of its pouch along the cord above the testicle, there is a thin septum between its cavity and that of the abdomen. If a protrusion occurs over this septum and the thin layer is pushed before it so as to encapsulate it, the hernia is said to be *encysted.* If, however, the protrusion is forced down behind the adhesion of the vaginal tunic at the deep opening, it constitutes *infantile hernia,* and in this variety there will be of course three layers of peritoneum to contend with in the event of an operation,—viz., the two layers of the tunica vaginalis and the proper sac of the hernia. It has been suggested that the anatomical arrangement of the parts in the encysted cavity favors the rupture of the septum above mentioned, and may explain the occurrence of congenital herniæ in adult life. Such herniæ would be better called *herniæ into the vaginal tunic,* as the term "congenital" applies truly to all these protrusions. Sometimes the vaginal tunic is closed above the testicle, while the outer layer of the peritoneum is not blended with the tissues of the cord: it is then known as the *funicular process,* giving its name to a hernia which may escape into it.

The complete closure of the tunica vaginalis is peculiar to man, and has been attributed to his adaptation to the erect posture. The manner in which the peritoneal process into the scrotum is separated from the abdomen is interesting. It first becomes obliterated at the deep opening and then at the top of the testicle, leaving between these points a loose tubular fold about the cord. This generally dwindles and appears as a fine band in front of the other tissues of the spermatic cord (Plate 69, Fig. 8, No. 5), but occasionally it remains free in part, and is then apt to become distended with fluid, producing *encysted hydrocele of the cord.* When inguinal hernia occurs in the female it is usually occasioned by the patent condition of the canal of Nuck (page 116), which is the analogue of the vaginal process in the male and allows the protrusion to pass along the course of the round ligament. The *seat of stricture* in oblique inguinal hernia is always at some point within the inguinal canal or at one of its extremities, most frequently at the deep opening. The course of the deep epigastric artery, as already described (page

75), is always along the inner margin of the deep abdominal opening upward toward the sheath of the rectus muscle, between the extra-peritoneal fascia and the peritoneum. In herniotomy for strangulation in the oblique form the constriction should be nicked with the bistoury directed upward and, in the author's opinion, parallel to the course of the artery, because in the presence of a tumor it will be necessarily pushed aside.

A knowledge of the anatomy of the various coverings is undoubtedly important, but undue stress has been laid on their number and origins, since in operating the only one that is distinctly recognizable is the cremaster. It is much more useful to understand the exact position of the abdominal openings, the course of the epigastric artery, and the construction of the inguinal tract.

The triangular intervals upon either side of the lower part of the anterior wall of the abdomen, named *Hesselbach's triangles*, have already been described (page 19). They are each bounded externally by the deep epigastric artery, internally by the tendon of the rectus muscle, and below by Poupart's ligament. These spaces are more or less diminished by the conjoined tendons which stretch across their inner portions. The remaining portion is remarkably thin, being composed only of the extra-peritoneal fascia, the pubic attachment of the aponeurosis of the external oblique muscle, the superficial fascia, and the skin. The inner inguinal pouch (page 19) of the peritoneum is behind it, and the superficial abdominal opening is in front. These conditions would seem to offer an easy route for a hernia at this point; but such a hernia is very rare, and when it does occur it is probably due to some change in the position of the corresponding hypogastric cord, which would necessarily exert an influence upon the inner inguinal pouch. The cord is often found shorter on one side than on the other, so that it does not come so far forward, and consequently there is an unequal folding of the peritoneum. A protrusion through this part of the abdominal wall is called a *direct inguinal hernia*, and it would receive as coverings, besides its *sac*, which is formed from the inner inguinal pouch of the peritoneum, the sub-serous tissue, the extra-peritoneal fascia, the intercolumnar

fascia, the superficial fascia, and the skin. There are others variously ascribed to it as being derived from the conjoined tendon or from one or other of its component parts (either the tendon of the internal oblique or the tendon of the transversalis), and the hernia occasionally appears to issue from between the fibres of the conjoined tendon itself. These may probably all be accounted for by the internal oblique or the transversalis muscle being attached lower down upon Poupart's ligament than it is ordinarily. The chief point of practical interest is the disposition of the epigastric artery, which, being always to the outer side of any protrusion occurring below the deep abdominal opening, can be avoided if the knife be used so as to nick the stricture upward and inward toward the middle line.

The weak place below Poupart's ligament is called the *femoral opening*. Like the deep abdominal opening, it can be said to exist only when the fasciæ in its locality are separated artificially by the knife or by the pressure of a hernia. It can be best understood by first considering the general arrangement of the parts which pass beneath Poupart's ligament, usually called in this connection the *femoral arch*. The interspace formed by the expansion of the latter between the iliac and pubic spines is divided by a band of fibres passing from its under surface to the ilio-pectineal eminence (page 103). This band is the *ilio-pectineal ligament*, on the outer side of which is the *lacuna musculosa* for the passage of the ilio-psoas muscle (page 69), and on the inner side the *lacuna vasculosa* for the femoral vessels. Upon the inner side of the sheath of the femoral vessels, between the vein and Gimbernat's ligament (page 96), there is a small space, filled with areolar tissue, which corresponds to the femoral opening when it is formed as above described. To locate it upon the surface it is necessary to ascertain the exact point of attachment of Poupart's ligament at the spine of the pubis (page 83). The position of the femoral opening is just below and to the outer side of this point.

The skin at the upper part of the thigh is loosely connected with the subcutaneous fascia along Poupart's ligament, over the pubis, and at the great trochanter. The superficial fascia is thick, and contains much

fat in its meshes. It is arranged in two layers, between which are the superficial vessels, superficial nerves, and lymphatic glands. The superficial layer is continuous with the superficial fascia of the abdomen above and with that of the thigh below. The deep layer of the superficial fascia blends with the fascia lata below Poupart's ligament and about the *saphenous opening.* The latter is a large oval-shaped aperture in the fascia lata at the upper and inner part of the thigh (Plate 70, Fig. 1, No. 24), through which the superficial vessels pass to and from the femoral vein and femoral artery beneath. The deep layer of the superficial fascia is here called the *cribriform fascia,* because it is perforated by these vessels. This fascia must be removed before the saphenous opening can be definitely seen. The superficial vessels are the epigastric, circumflex iliac, and external pubic arteries and their veins, which have already been described (page 84). Besides these there is the *internal saphenous vein* (Plate 70, Fig. 1, No. 11), which is the large vein ascending upon the inner side of the thigh to pass through the saphenous opening and empty into the femoral vein. The lymphatic vessels which accompany the above vessels terminate in the lymphatic glands which overlie the saphenous opening (Plate 70, Fig. 1, No. 8).

The *superficial lymphatic glands* are disposed in two groups. The glands above Poupart's ligament are described on page 84; those below it surround the saphenous opening and receive the lymphatic vessels from the lower extremity. Two of these, called the *femoral lymphatic glands,* are oblong in shape and lie along the outer and inner sides of the saphenous vein (Plate 68, Fig. 1, No. 8). The *nerves* which supply the skin of this locality are the branches of the ilio-inguinal, on the inner side of the internal saphenous vein, the genito-crural, on the outer side of the vein, and the middle and external cutaneous branches of the anterior crural, on the front and outer side of the thigh (Plate 68, Fig. 1).

The *fascia lata* is the dense fibrous sheath of the thigh (page 245). It is especially thick and strong in the neighborhood of Poupart's ligament, where it consists of two portions, the *iliac* and the *pubic,* which are peculiarly disposed above and below the sheath of the femoral

vessels so as to form the *saphenous opening* already referred to. The *iliac portion of the fascia lata* is attached externally to the crest of the ilium, and thence along the lower anterior border of Poupart's ligament all the way to the spine of the pubis, where it joins Gimbernat's ligament on the ilio-pectineal line. From this broad attachment it is reflected downward and outward over the femoral vessels four centimetres, or about an inch and a half, and then turns upward and inward over the subjacent adductor longus and pectineus muscles, and, passing beneath the femoral vessels, becomes continuous with the ilio-psoas fascia in relation to the capsule of the hip-joint. This portion is attached to the pectineal line and to the pubic arch, and is called the *pubic portion of the fascia lata.* The margins of the saphenous opening thus formed by the separation of the fascia lata are connected by the cribriform fascia as above described. When this is removed, the outer border of the saphenous opening appears as a crescent-shaped arch,—the *falciform process* (*of Burns*). The upper portion of this border in relation to Gimbernat's ligament is called the *ligament of Hey.* It is noteworthy, as it constitutes the superficial seat of stricture in femoral hernia (page 99.) It is the superficial end of the so-called femoral canal, and is therefore analogous to the superficial abdominal opening in inguinal hernia.

From the above it will be understood that the inner or pubic portion of the fascia lata is on a plane posterior to that of the outer or iliac portion. *Gimbernat's ligament* is the portion of the aponeurosis of the external oblique muscle which is reflected for two and a half centimetres, or about an inch, along the pectineal line. It is semilunar in form, with its free border directed toward the femoral vein, and in the erect posture it is placed nearly horizontal. It can be best seen by examining the lower part of the anterior wall of the abdomen from within, after the peritoneum has been removed (Plate 76, Fig. 2, No. 8). In the female this ligament is usually shorter than in the male, being rarely over two centimetres, or three-fourths of an inch, in length. When the iliac portion of the fascia lata is removed, the anterior portion of the sheath of the femoral vessels is exposed. It is formed by the downward expan-

sion of the extra-peritoneal fascia (page 16), in the same manner as the posterior portion of the sheath is formed by the ilio-psoas fascia (page 69). Both of these fasciæ join externally and internally to the vessels, thus completing the sheath. The sheath is intimately adherent to the vessels below the saphenous opening, but opposite Poupart's ligament it is loose, allowing the efferent and afferent vessels to pass through it, among the latter the most conspicuous being the saphenous vein. Occasionally there is a specialized band of fibres, derived from the extra-peritoneal fascia, which extends across the sheath of the femoral vessels to be inserted behind the attachment of the conjoined tendon (page 14) and blends with Gimbernat's ligament on the pectineal line. It is called the *deep femoral arch.* When the anterior portion of the sheath is removed, its interior appears to be funnel-shaped, and to consist of three compartments formed by strong septa, the femoral artery occupying the outer one, the femoral vein the middle one, and some lymphatic vessels, with usually a small lymphatic gland, the inner one. The latter, or the lymphatic compartment, is much smaller than the others, and extends only one centimetre, or about three-eighths of an inch, below Poupart's ligament. It is closed above at the margin of the pelvis by a thin layer of the sub-serous tissue, called the *septum crurale* or *septum femorale* (or *fascia of Cloquet*). The lymphatic compartment is liable to become the seat of a hernia, and is therefore known as the *femoral canal.* In the female this space has somewhat weaker boundaries than in the male, although it is not really larger. It is formed in front by the portion of the extra-peritoneal fascia which contributes to the sheath, behind by the ilio-psoas fascia constituting the under portion of the sheath, internally by the union of these fasciæ in relation to Gimbernat's ligament, and externally by the septum separating it from the femoral vein. On removal of the sub-serous tissue, or septum femorale, there is an opening about the size of the tip of the index finger, which is the **femoral opening.** It is usually larger in the female than in the male, partly on account of the greater width of the female pelvis, but its size varies according to the breadth of Gimbernat's ligament. It is surrounded by unyielding structures,—viz., in front by

PLATE 65.

Figure 1.

The uterus and its appendages removed from the body. The anterior layers of the broad ligaments are dissected off so as to expose the branches of the uterine arteries.

1. The fundus of the uterus.
2. The ligament of the right ovary.
3. The right Fallopian tube.
4. The right ampulla or pavilion.
5. The fimbriated extremity of the right Fallopian tube.
6. The right ovarian artery.
7. The right ovary.
8. The posterior layer of the broad ligament.
9. The right round ligament.
10. The right uterine artery.
11. The posterior wall of the vagina.
12. The ligament of the left ovary.
13. The left Fallopian tube.
14. The left ampulla or pavilion.
15. The infundibulo-ovarian fimbria.
16. The left ovary.
17. The body of the uterus.
18. The neck of the uterus.
19. The left round ligament.
20. The left uterine artery.
21. The anastomosis of the cervical arteries.
22. The os uteri externum.

Figure 2.

Posterior view of the spleen, the pancreas, and the descending portion of the duodenum. The pancreas is dissected so as to show the pancreatic ducts, and the duodenum opened to show the opening for the ductus communis choledochus.

1. The commencement of the descending portion of the duodenum.
2. The cystic duct.
3. The hepatic duct.
4. The accessory pancreatic duct.
5. The splenic artery.
6. The splenic vein.
7. Gastric branches of the splenic artery.
8. Penetration of branches of the splenic artery into the substance of the spleen.
9. The hilum of the spleen.
10. The costal surface of the spleen.
11. Penetration of branches of the splenic artery into the substance of the spleen.
12. The tail of the pancreas.
13. Pancreaticæ parvæ arteries.
14. The main pancreatic duct.
15. The termination of the ductus communis choledochus in the wall of the duodenum.
16. The termination of the descending portion of the duodenum.

Figure 3.

The right testicle and epididymis and the spermatic cord laid open to show the vas deferens and spermatic vessels.

1. The cord covered with part of the cremaster muscle.
2. The vas deferens.
3. The plexus of spermatic veins.
4. The artery of the vas deferens.
5. The body of the epididymis.
6. The tunica vaginalis reflected.
7. The spermatic artery.
8. The tunica vaginalis reflected.
9. The head of the epididymis.
10. The hydatid of Morgagni.
11. The testicle covered with the tunica albuginea.
12. The tail of the epididymis.

Figure 4.

Posterior view of the cæcum, showing the vermiform appendix held by a fold of the peritoneum to the back wall of the cæcum; also the termination of the ileum.

1. The commencement of the ascending colon.
2. The tæniæ coli.
3. The termination of the ileum.
4. The tip of the vermiform appendix.
5. The caput cæcum coli.

Figure 5.

The cæcum viewed from in front. A section is removed from the bowel to expose the ileo-cæcal and ileo-colic valves, also the opening into the appendix vermiformis.

1. The commencement of the ascending colon.
2. The tip of the vermiform appendix.
3. The opening into the vermiform appendix.
4. One of the plicæ sigmoideæ.
5. The ileo-colic valve.
6. The ileo-cæcal valve.
7. The termination of the ileum.
8. The caput cæcum coli.

N.B.—This and Figure 4 are from a specimen which was carefully washed, inflated, and dried. The natural appearance is well preserved.

Fig 3

Fig 4

Fig 5

Poupart's ligament and the deep femoral arch when it is present, behind by the horizontal ramus of the pubic bone covered by the pectineus muscle and the pubic portion of the fascia lata, on the outer side by the septum separating it from the femoral vein, and on the inner side by the sharp border of Gimbernat's ligament, the conjoined tendon of the internal oblique and transversalis muscles, and the extra-peritoneal fascia and the attachment of the fibres of the deep femoral arch. The femoral opening, when it is cleared of the tissues which naturally occupy it, both feels and looks more like a *ring* than any of the other openings or weak places in this region. In the male the spermatic cord, and in the female the round ligament, is immediately over the anterior border of the femoral opening. When examined from within, as in Plate 76, Figs. 1 and 2, the intimate relations of the vessels to the opening can be best appreciated. The femoral vein is on the outer side, and the *deep epigastric artery,* after its origin from the external iliac artery, passes close to the upper and outer border.

Very often (about once in every three or four bodies) the *obturator artery,* which usually arises from the internal iliac (Plate 76, Fig. 1, No. 18), is given off from the epigastric or arises in common with it from the external iliac. When it does so it holds very different relations to the femoral opening, which deserve close attention in regard to the operation for relief of deep strangulation in femoral hernia. Sometimes the obturator artery descends close to the external iliac vein to reach the obturator foramen, at other times it curves along the border of Gimbernat's ligament (Plate 76, Fig. 2, Nos. 5 and 12). In the former case it is out of the way in the operation, in the latter it is directly in the way.

A *femoral hernia* is a protrusion of a portion of the intestine, covered by its sac, through the femoral opening. It descends a very little way below Poupart's ligament and projects as a small tumor in front of the pectineus muscle. It is generally arrested by the lower margin of the saphenous opening, but if the hernia increases in size it is directed forward and then upward over Poupart's ligament, where the subcutaneous tissue offers less resistance. The coverings which a femoral hernia would

receive in pursuing such a course are, from within outward, besides its sac of the peritoneum, the sub-serous tissue, the septum femorale, the anterior portion of the femoral sheath, the cribriform fascia, the superficial fascia, and the skin. It should be noted that the sub-serous tissue in relation to the femoral opening often contains a considerable amount of fat, which might be mistaken for omentum covered with peritoneum. The sub-serous tissue is also called the *fascia propria* of a femoral hernia.

The seat of stricture is usually at the margin of Gimbernat's ligament or at the margin of the saphenous opening. In either case it should be divided very guardedly in a direction upward and inward. The dangers of wounding a blood-vessel in this operation have been very much exaggerated, for, unless the operator is foolhardy, the artery, whether it should be the epigastric or the obturator, as above explained, will in all probability be pressed aside by the hernial tumor. It is not likely that any one who is properly fortified with a knowledge of the relations of the structures in this region will use the knife rashly in operating; and the author believes it only right to state that, after considerable experience and careful inquiry, he has not been able to obtain authentic information of a single mishap from the wounding of an artery in any hernia operation. Would that anatomy could give equal assurance against the occurrence of shock and inflammation!

With regard to the anatomy of the parts concerned in inguinal and femoral hernia, it should be understood that there are many changes and complications which are induced by the hernial tumor in almost every instance, so that it may be truly said that the surgeon who has had experience in operating upon this region never approaches a case of herniotomy without expecting to encounter some unusual condition of the parts involved. Every hernia has its peculiarities, and no two cases occurring in the same locality and under the same conditions of age or sex are alike.

THE REGION OF THE PELVIS.

The pelvis (Plate 27, Vol. I., and Plate 82, Fig. 1) is peculiarly constructed, so that it serves not only to protect the viscera which it contains and to support some of the viscera of the abdomen, but also to transmit the weight of the body to the lower extremities; it also affords attachment to the muscles which steady the trunk and move the thighs.

In the adult the **pelvis** (or *basin*) consists of four bones,—the two ossa innominata, the sacrum, and the coccyx. These bones are arranged in the form of an oblique arch with broadly-expanded wings. The innominate bones join with each other in front, constituting the *pelvic girdle*, and receive the sacrum between them behind in the manner of a keystone to an arch. The strength and immobility of these bones adapt the pelvic girdle to the support of the body in the upright position, and are in marked contrast with the lightness and mobility of the shoulder-girdle (page 323, Vol. I.). The alteration in form and obliquity which the pelvis undergoes from infancy to puberty is in accordance with its adaptation to the transmission of the weight of the body in the standing and sitting postures. These are effected by two arches, or rather two modifications of the pelvic arch. In standing, the arch is represented by the sacrum and its junction with the two iliac bones, the acetabula, and the intervening masses of bone. In sitting, the arch consists of the sacrum and the iliac articulations, the tubera ischii, and the intervening masses of bone. These arches have been called the *femoro-sacral* and the *ischio-sacral* (Morris). The sacrum and symphysis pubis are common to both arches. The obliquity of the pelvic arch assists in distributing the effects of shocks received from below, as in jumping. The centre of gravity in the adult is directly over the middle of a line drawn across the heads of the two femora, and corresponds to a point just above the promontory of the sacrum. It should be remembered in making measurements that the base of the sacrum is nine and a half centimetres, or about three and three-fourths inches, above the upper border of the symphysis pubis, and that the end of

the coccyx is a little higher than its lower border. This naturally affects the brim of the pelvis, or ilio-pectineal line, the plane of which in the erect position is inclined to the horizon at an angle of sixty degrees.

Each *innominate bone* (haunch- or hip-bone) is an irregularly-shaped bone which before puberty is composed of three segments,—the ilium, the ischium, and the pubis. They meet at the *acetabulum*, the large cup-shaped cavity for the reception of the head of the femur, near the middle of the outer surface of the bone, and are united by a Y-shaped cartilage. Although in the adult they become firmly consolidated into one innominate bone, the several names are usually associated with their respective portions, each of which presents many prominences which are constantly referred to as *landmarks*. The *ilium* is the broad expanded portion which forms the prominence of the hip and supports the flank. It consists of a *body*, which forms less than two-thirds of the acetabulum, and the *ala*, or wing, which ends above in a thick, irregularly-twisted *crest*. This is marked by three faint lines, an outer, a middle, and an inner, which respectively give attachment to the external oblique, internal oblique, and transversalis muscles. The crest is subcutaneous, and presents at each end a superior spinous process. Below the anterior superior spine there is the superior iliac notch, which is separated from the inferior iliac notch by the rough anterior inferior spine. The anterior superior spine and the superior notch afford attachment to the sartorius muscle, the inferior spine gives attachment to the straight tendon of the rectus femoris muscle, and the inferior notch supports the tendon of the ilio-psoas muscle. The posterior superior spine is separated from the posterior inferior spine by the posterior iliac notch. Below the posterior inferior spine is the greater sciatic notch. The outer surface of the ilium, or the *dorsum* (Plate 83, Fig. 1), is convex in front and concave behind. It presents various curved lines and rough surfaces for the attachment of the glutei muscles, and ends below at the border of the acetabulum, above which it is rough for the insertion of the capsular ligament of the hip-joint and marked by a depression behind the inferior spine for the reflected tendon of the rectus femoris muscle. The

inner surface of the ilium, or the *venter* (Plate 27, Vol. I.), is smooth and concave, and gives attachment to the iliacus muscle. It ends below in the ilio-pectineal line. Posterior to this line is the *auricular facet*, for articulation with the sacrum. The *ischium* is the inferior and strongest portion of the entire innominate bone. It consists of a mass which terminates below in a large rough area, the *tuberosity*, upon which the weight of the body in the sitting position is received, and a thinner ascending portion, the *ramus*. At the junction of the body with the ramus there is a sharp process, the *spine of the ischium*, projecting inward. It separates the greater and lesser sciatic notches. The body of the ischium forms more than two-fifths of the acetabulum. The *pubis* consists of a body and a horizontal and a descending ramus. The latter is continuous with the ramus of the ischium. The upper border of the body presents a sharp tubercle, the *spine of the pubis*, whence a ridge extends backward and forms part of the ilio-pectineal line. The *crest of the pubis* is an everted obtuse ridge internal to the spine. Its internal border is oval and transversely grooved for the adaptation of the fibro-cartilage placed between it and the corresponding part of the opposite bone, their junction being called the *symphysis pubis* and forming the front of the pelvis. The *horizontal ramus* extends outward to join the ischium and ilium in forming the acetabulum, to which it contributes less than one-fifth. At the junction of the horizontal ramus with the ilium there is a prominence over the anterior part of the acetabulum, the *ilio-pectineal eminence.*

The *acetabulum* is a nearly hemispherical cavity formed by the above bones, and presents downward, outward, and forward, for the reception of the head of the femur. It is bounded by a sharp border, interrupted inwardly by the *cotyloid notch*, which communicates with an irregular fossa, the *fovea acetabuli*, at the bottom of the acetabulum, which lodges a cushion of adipose and connective tissue and the expansion of the ligamentum teres of the hip-joint (page 232).

Between the ischium and the pubis there is a large aperture,—the *thyroid* or *obturator foramen*,—which gives lightness without diminishing the strength of the pelvic bones. In the recent state it is closed by a

membrane, the obturator membrane. Beneath the horizontal ramus of the pubis there is an oblique channel for the passage of the obturator vessels and nerve. The obturator foramen is an irregular oval in the male, while in the female it is shorter and broader and triangular in shape.

Each innominate bone has eight centres of ossification, which appear at varying intervals from the ninth week of fœtal life to the age of twenty-one years. There are three primary centres: one for the ilium, in the ninth week; one for the ischium, in the twelfth week; and one for the pubis, in the sixteenth week. The Y-shaped cartilage in the acetabulum, separating the three segments, begins to ossify about the sixth year, and unites with the ilium and ischium in the fourteenth year, with the pubis a year later, and is completely consolidated in the seventeenth year. Traces of the original separation are frequently observed as slightly-roughened lines in the site of the cartilage. There are four epiphyses: one along the crest of the ilium, which begins to ossify at fifteen years of age and is completed at twenty-one; a second over the ischial tuberosity, appearing at sixteen and completed at twenty; a third over the anterior inferior spine, appearing at sixteen and completed at nineteen; and a fourth over the crest of the pubis, appearing at seventeen and completed at twenty-one. A knowledge of these facts is often of value in medico-legal practice, as they account for certain conditions, as, for example, the detachment of the rim from the iliac crest by violence, or the separation of the anterior inferior spine of the ilium by contraction of the rectus muscle. During childhood, if pus forms in hip-joint disease the cartilage in the floor of the acetabulum is liable to become disintegrated, so that the pus may gain an entrance into the cavity of the pelvis. The structure of the innominate bone consists of a layer of cancellous tissue of varying thickness enclosed between an outer and an inner layer of compact tissue. In the middle of the venter of the ilium (the iliac fossa) the cancellous tissue is deficient, so that the bone is exceedingly thin, while in the tuberosities it is most abundant. About the acetabulum the compact layers are especially dense.

The innominate bones are immovably joined with each other in front, forming the *symphysis pubis*, and with the sacrum behind, forming the

sacro-iliac articulation, on each side. At the pubes there is always an intervening disk of fibro-cartilage, which is more or less complete, and is covered laterally with a lamina of hyaline cartilage which connects it with the bones. The disk often presents an irregular cleft in the centre. This is nearer to the posterior than to the anterior surface, and is generally larger in the adult female than in the male. It is not lined by synovial membrane. The joint is strengthened anteriorly by bands of cross-fibres derived from the periosteum and the tendinous expansions of the abdominal muscles, and posteriorly by a thinner expansion of the periosteum. These bands of fibres are known respectively as the *anterior*, *posterior*, *supra-pubic*, and *sub-pubic ligaments*. The latter is most pronounced, and smooths the under border of the pubic arch. The *sacro-iliac articulation* is a synchondrosis by which the rough auricular facet of the ilium is attached to the corresponding surface of the sacrum by means of an irregular fibrous capsule. The surfaces are provided with a thin layer of cartilage, and are united by irregular plates of fibro-cartilage moistened by synovial fluid. The joint is provided with an *anterior sacro-iliac ligament* and a *posterior sacro-iliac ligament*, which consist of bands of fibres which pass respectively in front of and behind the contiguous bones. The posterior is much stronger and thicker than the anterior. There are three important ligaments to this joint. The *ilio-lumbar ligament* is a strong band which extends from the transverse process of the last lumbar vertebra to the crest of the ilium, the base of the sacrum, and the anterior sacro-iliac ligament. It is the thickened lower border of the sheath of the quadratus lumborum muscle. The *greater sciatic ligament* arises by a broad expansion from the posterior inferior spine and adjacent gluteal area of the ilium, and from the lateral mass of the sacrum by a series of irregular lamellæ, and descends outward to the inner margin of the tuberosity of the ischium, along which it is prolonged to the pubic arch. Its lower border is continuous with the attachment of the biceps femoris muscle at the tuberosity of the ischium, and is considered to have been originally the sacral continuation of that muscle. The *lesser sciatic ligament* arises from the sacrum and coccyx by a wide expansion under cover of the *greater* ligament,

PLATE 66.

Figure 1.

The abdomen of a still-born child at full term, opened to show the great size of the liver, the left lobe of which extends into the left hypochondriac region, completely concealing the stomach. The peculiar looped condition of the colon is also shown as it crosses over the lower part of the abdominal cavity, covering the small intestine.

1. The right lobe of the liver.
2. The upper loop of the colon.
3. The lower loop of the colon.
4. The left lobe of the liver.

Figure 2.

The liver raised to show the shape and position of the stomach. (The same as Figure 1.)

1. The liver.
2. The colon.
3. The stomach.
4. The gastro-colic fold of the peritoneum.

Figure 3.

The relations of the bladder and uterus six weeks after birth.

1. The small intestine.
2. The bladder.
3. The left hypogastric cord.
4. The fundus of the uterus.

Figure 4.

Dissection of the abdomen of a child four months after birth, showing the condition of the large and the small intestine at that period; also the cords, meeting at the umbilicus, which are the remains of the obliterated umbilical vein, the right and left hypogastric arteries, and the urachus.

1. The liver.
2. The round ligament of the liver, or remains of the umbilical vein.
3. The colon.
4. The cæcum.
5. The right hypogastric cord.
6. The bladder.
7. Portion of the anterior wall of the abdomen reflected, showing the deep epigastric artery.
8. The transverse portion of the colon.
9. The colica media artery.
10. The umbilicus.
11. The small intestine.
12. The obliterated urachus.
13. The left hypogastric cord.
14. The deep external circumflex iliac artery.
15. The left femoral artery and vein.
16. The left spermatic artery.

and is attached to the spine of the ischium. It is the condensed sheath of the coccygeus muscle. By their peculiar disposition the great sciatic notch on the posterior border of the ilium is converted into two foramina. The *greater sciatic foramen* is thus formed by the lesser sciatic ligament, and the *lesser sciatic foramen* by the greater sciatic ligament.

The *obturator membrane*, which closes in the obturator foramen except at its upper and outer part for the passage of the obturator vessels and nerve, resembles the interosseous membrane of the forearm. It is composed of thin, irregular lamellæ of fibres, from the outer surface of which a more or less defined band passes to the capsule of the hip-joint. The outer surface of the membrane and the surrounding bony margin give attachment to the external obturator muscle (page 261), and the inner surface of the membrane and the contiguous surface of the pelvis give attachment to the internal obturator muscle (page 224).

The *sacrum* and the *coccyx* belong essentially to the vertebral column, but, as they form when taken together the back wall of the pelvic cavity, their structure should be considered in this connection. In childhood the *sacrum* consists of five separate *sacral vertebræ*, which successively decrease in size from above downward, so that at puberty, when they are consolidated into one bone owing to the intervertebral disks becoming ossified, it appears as an inverted triangular bony mass supporting the vertebral column and receiving at its sides the pelvic girdle. The sacrum presents anteriorly a concave surface with its upper end or *base* projecting forward and forming with the last lumbar vertebra the *promontory* or *sacro-vertebral angle*. Its lower end, or *apex*, articulates with the coccyx. The anterior or pelvic surface is smooth and formed in the middle by the bodies of the sacral vertebræ, with intervening transverse ridges indicating the former position of the intervertebral disks. At the outer extremity of each transverse ridge there is a round foramen for the anterior branches of the sacral nerves. These are the *anterior sacral foramina*. There are four upon each side, corresponding to the intervertebral foramina of the spinal column above. Externally to the foramina the bone consists of strong processes, —the *wings* or *lateral masses*,—which are grooved for the lodgement of

the sacral nerves as they pass forward to form the sacral plexus. The posterior or dorsal surface of the sacrum is convex, and presents in the middle the rough spinous processes of the sacral vertebræ, often united into a vertical ridge owing to ossification of the supra-spinous ligaments. On either side are the laminæ, of which the third and fourth are usually incomplete, thus constituting the *hiatus sacralis.* The articular processes are also ankylosed, the fifth sacral projecting downward as the *cornua sacralia.* Externally to the articular processes are the *posterior sacral foramina,* which give egress to the posterior sacral nerves. These are smaller than the anterior foramina, with which they communicate. The sides of the sacrum are provided above with *auricular facets* for articulation by synchondrosis with the corresponding facets of the ilia, and below these they present the *lateral tuberosities* for the attachment of the greater and lesser sacro-sciatic ligaments, and terminate in the *inferior lateral angles.* If a vertical section is made through the centre of the sacrum, it will be seen that the ossification of the bodies of the sacral vertebræ is mainly at their circumference, a wide central interval being left, which is occupied in the recent state by intervertebral substance. The ossification is usually found to be more complete between the lower segments than between the upper ones. Ossification begins by three primary centres for each of the sacral vertebræ, which appear as early as the eighth week. Later centres arise for the lateral portions, and others again for epiphyseal plates connected with the articular surfaces, the spinous processes, the auricular facets, and the tuberosities, so that there are in all thirty-seven centres for the sacrum. The fusion of all the pieces of the sacrum is generally completed about the twenty-sixth year. The *sacral canal,* exposed upon vertical section of the bone, is a continuation of the vertebral canal. It follows the curvature of the bone, and opens into the anterior and posterior sacral foramina by the intervertebral canals. The structure of the sacrum corresponds to that of the vertebræ. The lateral masses are provided with especially hard plates of compact tissue upon their surfaces, in accordance with the adaptation of the bone to the strain it receives in serving as the keystone to the pelvic arch, already described (page 101).

The *coccyx* is composed of four or five segments, or rudimentary coccygeal vertebræ, which after adult age usually consolidate into one or two pieces. In advanced life the entire coccyx is often found ankylosed with the sacrum, forming one bony mass. Commonly, however, the lower segments unite, and the upper or first coccygeal vertebra remains separate. This resembles very closely the last sacral vertebra, having between the body and the lateral processes notches which are converted by the greater sacro-sciatic ligaments into foramina for the fifth sacral nerves. On the posterior surface of the body there are two processes,—the *cornua coccygea,*—which project upward to join with the descending cornua of the sacrum. Ossification does not take place in the coccyx until after birth, when a centre appears in each segment,—in the first about the fourth month, in the second at the fifth year, in the third at the ninth year, and in the fourth at the sixteenth year. The segments are rarely united into one bony piece before the age of forty years. The sacrum and coccyx are connected by *anterior* and *posterior sacro-coccygeal ligaments.* The posterior serves to close the lower end of the spinal canal.

The pelvis, considered as a whole, is divided by the *linea ilio-pectinea* (or *ilio-pubic line*) and the promontory of the sacrum into the false pelvis and the true pelvis. The *false pelvis,* as already stated (page 19), is practically the lower part of the abdominal cavity, and corresponds to the hypogastric region, the wings of the ilia being the floors of the right and left iliac fossæ. The inferior plane or outlet of the pelvis in the dried preparation is very irregular, but in the recent state it is narrowed by the sciatic ligament into a lozenge-shaped opening (Plate 81). The *true pelvis* is the space below the linea ilio-pectinea. It is smaller than the false pelvis, but it is provided with more perfect walls, designed to contain the rectum, the bladder, and the internal generative organs. The upper aperture of the true pelvis is called the brim or *inlet,* the lower the *outlet,* and the space between them the *cavity of the pelvis.* The inlet is formed by the crest of the pubes, the linea ilio-pectinea, and the sacrum. It is heart-shaped and has three principal diameters, an *antero-posterior* (or conjugate) *diameter,* which

extends from the promontory of the sacrum to the symphysis of the pubes, a *transverse diameter*, which extends across the greatest width of the inlet from side to side, and an *oblique diameter*, which extends from the ilio-pectineal eminence on one side to the sacro-iliac articulation on the other. The average measurements of these diameters are as follows: the antero-posterior, in the male one hundred and four millimetres, or four inches, in the female one hundred and twenty-three millimetres, or four and three-fourths inches; the transverse, in the male one hundred and seventeen millimetres, or four and a half inches, in the female one hundred and thirty-six millimetres, or five and one-fourth inches; the oblique, in the male one hundred and ten millimetres, or four and one-fourth inches, in the female one hundred and thirty millimetres, or five inches. The *cavity* is bounded anteriorly by the symphysis of the pubes, posteriorly by the concavity of the sacrum and the coccyx, and laterally by the inner surfaces of the ischii. The depth of the cavity is thirty-nine millimetres, or an inch and a half, at the pubic symphysis, ninety-one millimetres, or three and a half inches, at the middle, and one hundred and seventeen millimetres, or four and a half inches, from the promontory of the sacrum to the tip of the coccyx. These measurements show that the cavity of the pelvis is a curved passage-way, with the greatest depth posteriorly and the greatest breadth in the middle. The *outlet of the pelvis* is bounded in front by the rami of the ischii and pubes and the sub-pubic ligament, laterally by the tubera ischii and the greater sciatic ligaments, and behind by the coccyx (Plates 79 and 81). The diameters of the outlet are an *antero-posterior diameter*, which extends from the tip of the coccyx to the lower border of the symphysis pubis, and a *transverse diameter*, which extends between the posterior borders of the tubera ischii. The average measurement of the former is in the male ninety-seven millimetres, or three and three-fourths inches, and in the female one hundred and thirty millimetres, or five inches; of the latter, in the male ninety-one millimetres, or three and a half inches, and in the female one hundred and twenty-three millimetres, or four and three-fourths inches.

It has been previously stated (page 102) that the pelvis is placed

obliquely with regard to the trunk of the body, so that in the erect position the plane of the inlet of the true pelvis forms an angle of about sixty degrees with the horizon. The shape of the pelvis is much affected by the curving forward of the lower part of the sacrum, which not only serves to support the viscera but also plays an important part in the act of parturition. If all the antero-posterior diameters of the true pelvis were bisected, the *axis of the pelvis* would be found to form a curved line corresponding to the curve of the sacrum.

The pelves of the adult male and adult female present many points of contrast, some of which are noticeable even at birth. In the young child the pelvis is relatively very small in proportion to that of the adult, and at puberty there are very slight differences between the male and the female, but as growth progresses in proportion to the sexual requirements the characteristic differences are well marked. The bones of the *male pelvis* become more rough and massive, and its cavity is deeper and narrower, owing to the sub-pubic arch being more acute and to the consequent nearer approach of the ischial tuberosities. The obturator foramina are ovoidal in shape, larger, and directed vertically. The bones of the *female pelvis* are lighter and more expanded, the muscular impressions are less pronounced, and the cavity is shallower and more capacious, owing to the greater width of the pubic arch, to the sacrum being less curved and its promontory being less projecting, and to the ischial tuberosities being everted. The inlet and outlet are both larger, the obturator foramina are triangular, and the acetabula are farther apart.

The contents of the pelvic cavity are the bladder, the rectum, some of the organs of generation peculiar to each sex, the branches of the internal iliac artery and vein, the sacral plexus of nerves, and the pelvic sympathetic nerves and lymphatics.

The viscera of the female pelvis from before backward are the *bladder*, the *vagina*, the *uterus with its appendages*, and the *rectum*. Their relative positions can be best appreciated by comparing views of the pelvic organs as seen from above (Plate 70, Fig. 2, Plate 71, and Plate 72, Figs. 1 and 2) with side views as seen upon removal of one of the innominate bones (Plate 72, Fig. 3, and Plate 74).

When the abdomen is opened in front and the coils of the small intestine are raised out of the pelvis, the *reflections of the peritoneum over the pelvic viscera* can be traced. They have already been described in a general way (page 31). It should be especially noted that the anterior parietal layer of the peritoneum extends downward to the back of the pubic symphysis, where it is reflected over the summit of the bladder, the extent to which it is separated from the abdominal wall in this locality depending upon the degree of the distention of that organ. From the bladder the peritoneum passes downward to the neck of the uterus, forming the *vesico-uterine fold,* and expands laterally to the middle of the walls of the pelvic cavity, forming the *anterior layers of the broad ligaments.* It then ascends over the front of the uterus to the fundus, and, again expanding laterally, forms the *posterior layers of the broad ligaments,* and, thus including the uterine appendages, descends over the back of the uterus and the upper part of the posterior wall of the vagina, whence it ascends over the second portion of the rectum, forming the *recto-uterine fold.* It will therefore be seen that the *broad* or *lateral ligaments of the uterus* (Plate 71, Fig. 2, Nos. 7 and 13) consist of double folds of the peritoneum enveloping the uterus and containing on each side the Fallopian tube, the round ligament, and the ovary, and that they divide the pelvic cavity into two recesses, the anterior of which is occupied chiefly by the bladder and the posterior by the rectum. Besides the two lateral ligaments, the uterus possesses two *anterior ligaments,* formed by the reflected borders of the vesico-uterine fold, and two *posterior ligaments,* formed by the recto-uterine fold. The portion of the latter reflection of the peritoneum which is in relation to the upper part of the vagina is called the *recto-vaginal pouch* (*of Douglas*). This is within reach of the finger if it is passed along the upper part of the posterior wall of the vagina (Plate 73, Fig. 4, No. 7).

The normal position of the uterus, as it appears when the pelvis is viewed from above, depends upon the condition of the ligamentous folds of the peritoneum and the state of the bladder and rectum. When both the latter are empty, the *fundus* is directed upward and

forward. and is on a plane a little below the brim of the pelvis. It is often deflected to the right by the pressure of the sigmoid flexure of the colon where it terminates in the rectum, if that portion of the bowel is filled with fæces. Observations made by the author upon the cadaver have demonstrated the manner in which the vesico-uterine fold of the peritoneum acts upon the body of the uterus. If the bladder is gradually distended while the bowel is empty, the fundus is raised until the organ assumes a decided anteflexion. This is probably aided by the lateral traction upon it of the round ligaments, which are rendered tense by the vesical wall being lifted up, like the cords of a balloon. In cases of acute retroflexion knowledge of this fact may sometimes be of service.

It is a mistake to suppose that the broad ligaments maintain the position of a vertical septum across the pelvic cavity in which the uterus is suspended. If they ever do so it is only in the virgin state, for after the uterus has fulfilled its physiological function and the surrounding peritoneal ligamentous folds have been subjected to the strain involved by pregnancy and parturition the broad ligaments are relaxed, so that the uterus lies in a flaccid state between the rectum and the bladder. On account of this the various flexions and versions are apt to occur, but their occurrence does not always warrant the assumption that they require artificial support. There is usually too much meddling with this organ on account of some position which is considered incorrect, and the zealous practitioner might often do better if he would consider a little more closely the anatomical relations of the uterus instead of resorting to the use of a pessary. In very many cases where relief is thus obtained it is beyond doubt mainly through the wonderful connection between the hypogastric plexus of nerves and the imagination, for it is not a question of fitting the support to the uterus, but one of fitting the uterus to the support.

Upon either side of the fundus of the uterus, while the parts are *in situ* (Plate 71, Fig. 1), the **Fallopian tubes**, or *oviducts*, can be seen occupying the upper borders of the broad ligaments. Each tube appears slightly convoluted, and commences in a free funnel-shaped extremity—the *pavilion*—having fringe-like processes (the *fimbriæ*), one of

PLATE 67.

Dissection of the abdomen of a child four months after birth.

Figure 1.

The coils of the small intestine are drawn upward and the mesentery opened to show the branches of the superior mesenteric artery.

1. The ileum.
2. The branches of the superior mesenteric artery.
3. The cæcum.
4. The bladder drawn outward.
5. The right femoral artery and vein.
6. The jejunum.
7. The sigmoid flexure of the colon.
8. Branches of the inferior mesenteric artery.
9. The left femoral artery and vein.

Figure 2.

The small intestines, except the duodenum, are removed and the transverse colon drawn upward to show the branches of the inferior mesenteric artery. The cæcum is also drawn outward so as to display the vermiform appendix.

1. The transverse portion of the colon drawn upward.
2. The duodenum.
3. The trunk of the superior mesenteric artery.
4. The trunk of the superior mesenteric vein.
5. The cæcum drawn outward.
6. The vermiform appendix.
7. The termination of the sigmoid flexure of the colon.
8. The bladder.
9. The right femoral artery and vein.
10. The branches of the colica media artery.
11. The stomach.
12. The colica sinistra artery.
13. The inferior mesenteric artery.
14. The sigmoid flexure of the colon.
15. The deep circumflex iliac artery.
16. The left femoral artery and vein.

Figure 3.

The ascending and transverse portions of the colon are removed to show the shape of the stomach and the normal relations of the abdominal organs.

1. The liver.
2. The round ligament of the liver drawn aside.
3. The gall-bladder.
4. The duodenum.
5. The right kidney.
6. The right internal iliac artery and vein.
7. The right spermatic cord.
8. The right femoral artery and vein.
9. The cœliac axis.
10. The fundus of the stomach.
11. The trunk of the superior mesenteric vein.
12. The trunk of the superior mesenteric artery.
13. The sigmoid flexure of the colon.
14. The termination of the colon in the rectum.
15. The bladder.

Figure 4.

The stomach is drawn upward to show the relative positions of the pancreas, spleen, and kidneys.

1. The gastro-epiploica dextra artery.
2. The stomach drawn upward.
3. The hepatic artery.
4. The pyloric extremity of the stomach.
5. The pancreas.
6. The right lobe of the liver.
7. The trunk of the superior mesenteric vein.
8. The trunk of the superior mesenteric artery.
9. The right kidney.
10. The bladder.
11. The gastro-epiploica sinistra artery.
12. The spleen.
13. The splenic artery.
14. The left kidney.
15. The cut end of the duodenum.
16. The inferior mesenteric artery.
17. The sigmoid flexure of the colon.
18. The left external iliac artery and vein.
19. The termination of the colon in the rectum.
20. The left femoral artery and vein.

which, the *infundibulo-ovarian fimbria*, is attached to the corresponding ovary. As the canal of the Fallopian tube opens by the ostium abdominale into the peritoneal cavity, it establishes an indirect route to the exterior through the uterus and the vagina.

The ovaries are included in pouches, the *bursæ ovaricæ*, upon the posterior layer of the broad ligaments, and are attached to the pelvic wall just below the external iliac vessels (Plate 72, Fig. 2, No. 8) by the *ovario-pelvic folds*, and to the uterus by a band of connective tissue containing smooth muscle-fibres called the *ovarian ligaments*, and connected with the Fallopian tubes as above described.

The ovaries are originally formed in front of the fœtal kidneys, like the testicles (page 88), whence they gradually descend to their normal position below the brim of the pelvis in front of the sacro-iliac joints. In the virgin their long diameters are directed obliquely between the fundus of the uterus and the infundibula of the Fallopian tubes, but after pregnancy they are displaced, and, although they maintain their relations to the tubes, seldom return to their normal position.

The Fallopian tubes and ovaries do not appear as distinct structures when examined in the body, except when the layers of the broad ligaments are dissected, but rather as a confused loose mass extending laterally from the base of the uterus. This is partly due to the presence of a number of fine parallel tubules connecting with a main tube, constituting the rudimental *organ of Rosenmüller*, which occupies the interval between the Fallopian tube and the ovary within the layers of the broad ligament. This body is known as the *paroöphoron*, in contradistinction to the *epoöphoron*, which is an aggregation of some fœtal vestiges in juxtaposition with the ovary. These often present vesicular swellings, and may become the seat of cystic enlargement.

The round ligaments (Plate 71, Fig. 1, Nos. 8 and 17) appear as two stout cords, twelve and a half centimetres, or about five inches, in length, arising from the anterior upper angles of the uterus in front of the Fallopian tubes. Each ligament, consisting of unstriped muscle-fibres and blood-vessels in condensed areolar tissue, passes forward in the folds of the broad ligament to the deep abdominal opening on either

side behind the epigastric artery, where it enters the inguinal tract. Here there is already provided a process of the peritoneum, called the *canal of Nuck*, similar to the processus vaginalis (page 92), and the ligament pursues a course analogous to that of the spermatic cord in the male, eventually losing its character in the tissues over the pubes. In the adult there is rarely any trace of the peritoneal process or of the muscular tissue of the round ligament beyond the middle of the inguinal tract, and there is nothing to warrant the operation for *retrenching the round ligaments.* Occasionally, however, the canal of Nuck remains patent, and may become the seat of congenital hydrocele, or even of inguinal hernia.

Before removing the uterus and its appendages from the body for the particular study of their structure, it is well to dissect away carefully the peritoneum, in order to examine the complicated but very important *pelvic fascia*, and in doing so the amount of loose connective tissue between the peritoneum and the fascia should be noted, as its injury, in many of the operations practised in this region, is liable to result in *pelvic cellulitis.* The pelvic fascia and sub-serous connective tissue are fully described (page 126) with the anatomy of the male pelvic organs, and the especial differences of their relations to the female organs are there contrasted.

The urinary bladder of the female, if examined from above, when empty and relaxed (Plate 71, Fig. 2, No. 10), appears pressed vertically downward in the centre, and is flattened by the weight of the small intestines while they are *in situ.* When moderately distended (Plate 71, Fig. 1, No. 7), the summit of the bladder is spheroidal, and sometimes broader in the transverse diameter; it is very variable, however. Its normal capacity in the majority of cases equals that of the bladder in the male. There is a quantity of loose areolar tissue and fat back of the symphysis pubis, which allows the organ to be pressed upward and forward in pregnancy by the gravid womb.

The base of the bladder is in direct relation with the isthmus and anterior surface of the neck of the uterus and with the contiguous upper portion of the vagina, to which it is closely adherent (Plate 73, Fig.

2, and Plate 81, Fig. 1). The vesico-vaginal fascia connecting the neck of the bladder and the urethra with the anterior wall of the vagina is loose and thin, which explains the frequency of vesico-vaginal fistulæ.

The female urethra is four centimetres, or about an inch and a half, in length, and six millimetres, or about a quarter of an inch, in diameter, but very dilatable. It is widest at the neck of the bladder, narrowing as it passes through the sub-pubic fascia or triangular ligament in relation to the compressor urethræ muscle. Its course is curved upward and backward from the meatus (page 171).

The vagina is the musculo-membranous passage extending from the orifice between the nymphæ (Plate 79, No. 5) to the neck of the uterus, which it embraces (Plate 73, Fig. 2, No. 10), the posterior or rectal wall being attached two and a half centimetres, or about an inch, higher than the anterior or vesical wall. It is constricted at the orifice and at the neck of the uterus, so that the middle is the widest part of the passage. It is directed in a slightly-curved course upward and backward between the bladder and the rectum, its axis corresponding with that of the pelvic cavity and its outlet. The length of the vagina ordinarily is ten centimetres, or about four inches, on its anterior wall, and twelve and a half centimetres, or five inches, on its posterior wall. The walls are ordinarily in contact and flattened from before backward. When they are examined, their inner surface is found to be roughened toward the orifice, and to be smooth in the upper part, where the mucous lining membrane is continuous with that of the uterus. The roughness is due to the presence of a series of transverse ridges, the *rugæ* extending from longitudinal ridges, the *columnæ rugarum vaginalis,* one upon each wall. The rugæ have firm papillæ directed forward upon their margins, and are always more developed upon the anterior wall, especially in women who have not borne children. The mucous membrane of the vagina is of a pinkish color, covered with numerous conical papillæ, and has a thick lining of stratified squamous epithelium. In the lax submucous tissue there is an extensive venous plexus surrounded by layers of circular and longitudinal unstriped muscle-fibres, resembling erectile tissue. It also contains a number of mucous glands, which are largest and most numerous

about the neck of the uterus. The lower end of the vagina externally to the triangular ligament is surrounded by the *sphincter vaginæ muscle* (page 171). The walls of the vagina are very vascular, receiving their blood chiefly by the *vaginal* branches of the internal iliac arteries. The *veins* empty into the internal iliac veins. The *lymphatic vessels* pass to the pelvic glands in relation to the internal iliac vessels. The *nerves* are numerous, and are derived from the hypogastric plexus and the fourth sacral and pudic nerves. The vagina is in such close connection with the urethra that the latter can be detected through the anterior wall of the vagina, feeling like a thick cord. Posteriorly the connection between the vagina and the anterior wall of the rectum is very intimate for three centimetres, or about an inch and a half, above the anus, but above this point to a variable extent, from two and a half to six centimetres, or from one to two and a half inches, the walls of the rectum and vagina are loosely connected by areolar tissue which allows them to slide one upon the other. When the two canals are dissected apart to the extent of from nine to ten and a quarter centimetres, or from three and a half to four inches, the intervening pouch of the peritoneum is exposed (Plate 81, Fig. 2, No. 6), and the middle hæmorrhoidal and vaginal arteries can be seen upon each side.

The *rectum in the female* is more capacious and less curved than it is in the male. It is fully described in connection with the rest of the large intestine (page 45).

The uterus, or **womb** (Plate 71, Fig. 2, No. 14, and Plate 65, Fig. 1), is in the unimpregnated state a pear-shaped body measuring sixty-five millimetres, or about two and a half inches, in length, thirty-nine millimetres, or an inch and a half, in breadth, and twenty-six millimetres, or an inch, in thickness. Its position and relations have been described on page 112. The upper convex extremity is called the *fundus*, the central part is the *body*, and the lowest part, which gradually contracts downward from the body, is the *neck*, or *cervix*. The anterior surface of the body is somewhat flattened, while the posterior surface is convex, and the lateral borders, which are nearly straight, have attached to them on either side, from above downward, the Fal-

lopian tube, the round ligament, and the ligament of the ovary. These structures together with the ovary constitute the appendages of the uterus, and are all included within the layers of the broad ligaments (page 112).

The *cervix* projects into the vagina, and presents a central depression with a transverse or round orifice, the *mouth of the womb,* or the *os uteri externum,* which is enclosed by two convex borders forming the *lips.* The anterior lip is the thicker, and when exposed by a section through the pelvis and the organs *in situ* (Plate 73, Figs. 2 and 4) appears to descend lower in the vagina, although the posterior lip is really the longer, on account of the higher attachment of the posterior wall of the vagina (page 117). Owing to this disposition of the lips, they both come in contact with the posterior wall of the vagina while that passage is not distended, and thus upon making a digital examination of the vagina the anterior lip is always felt first. It should be noted that there is a marked difference in the condition of the uterus after death, when it appears firm and rigid, from its condition during life, when the body will be found to bend readily forward or backward on the cervix, the whole organ being softer and flexible.

The *cavity of the uterus* when it is exposed by an antero-posterior section appears as a nearly straight slit (Plate 73, Figs. 3 and 4), but when a transverse section is made it is triangular, with the base of the triangle at the fundus and the apex toward the cervix. The sides of the cavity are bowed convexly inward, so that the cavity is small in comparison with the size of the organ. At the upper angles the cavity is prolonged into narrow canals which are continued into the Fallopian tubes by minute orifices. At the inferior angle there is a constriction, the *isthmus,* or *os uteri internum,* which leads into the *cavity of the cervix.* The latter is elliptical or fusiform, and broadest at the middle, and presents both anteriorly and posteriorly a median longitudinal fold from which a series of oblique ridges diverge upward, appearing somewhat like the branches of a tree, and called the *arbor vitæ.* The structure of the walls of the uterus consists chiefly of non-striped muscular fibres, variously arranged as to their direction, but mainly aggregated

into three strata at the fundus and at the sides, and the internal mucous membrane. This is thin, soft, of a bright reddish color, is furnished with a layer of ciliated epithelium, and is continuous above through the free extremity of the Fallopian tubes with the cavity of the peritoneum, and below through the os uteri with the vagina. There is no distinct submucosa, but the inner layer of muscular fibres which corresponds to the muscularis mucosæ is enormously thick and forms the chief bulk of the uterine walls. Throughout the mucous membrane there are numerous orifices of the *uterine mucous glands*, which often appear between the ridges of the arbor vitæ as vesicular elevations and are called the *ovula* or *glandulæ Nabothi.* They secrete a thick, tenacious, glairy mucus. It is impossible to trace the muscular fibres in the unimpregnated uterus, as they are inextricably interwoven with the blood-vessels, nerves, and lymphatics.

The *arteries of the uterus and vagina* (Plate 65, Fig. 1, Nos. 10 and 21) are supplied by the uterine and vaginal branches of the internal iliac arteries, and intercommunicate with the ovarian arteries (page 125). These vessels all enter between the layers of the broad ligaments, and upon reaching the borders of the uterus anastomose freely with one another. The *veins* are much larger than the arteries, and upon issuing from the uterine walls form an intricate *superficial uterine plexus,* from which the main veins pass to empty into the internal iliac veins. During pregnancy the veins are called the *uterine sinuses,* as they then appear as large canals tunnelling through the spongy and extensible walls. The *nerves* of the uterus are derived from the third and fourth sacral nerves and from the hypogastric and ovarian plexuses. They accompany the ramifications of the blood-vessels upon the surface of the organ, but pursue an independent course within its substance. They are found chiefly about the neck and the adjoining part of the body, but appear to be absent from the os externum. Strange to say, the uterine nerves enlarge during pregnancy, like the blood-vessels.

The *lymphatic vessels* commence in freely-communicating lymph-spaces about the vessels, and pass with the vaginal lymphatics to the lymphatic glands about the internal iliac vein. The free arrangement of the lymph-

spaces in the walls of the uterus and the vagina explains the rapid absorption of septic matter from their surfaces.

Until the approach of puberty the uterus exists as an undeveloped, rudimentary organ. In the young child it projects considerably above the brim of the pelvis into the lower part of the abdominal cavity (Plate 66, Fig. 3, No. 4), and is wholly unlike what it becomes in the adult, not only in size, but also in its external and internal appearances. The cervix is longer, thicker, and firmer than the body. In truth, the organ can hardly be said to have any body in early life, for the arbor vitæ reaches to the top of the cavity, and there is no constriction or internal os. The upper portion, representing the body, is generally found thinner and more flexible. About the time of puberty the uterus and its appendages undergo rapid changes and acquire their adult character, the body of the organ growing faster than the cervix; and at the same time it assumes its normal position within the pelvis. The periodic changes attendant upon the function of menstruation are naturally accompanied by changes in the condition of the uterus. It is somewhat enlarged, owing to the afflux of blood in the vessels, the os externum is rounded, and the lips are swollen about it. The epithelial layer of the mucous membrane lining the cavity of the body softens and undergoes disintegration, and is shed with the blood from the ruptured capillaries, constituting the *menstrual discharge.* It is thought that this process of shedding the epithelium, which occurs at each menstruation from puberty to the menopause, prepares a nidus for the ovum if impregnated.

The changes which the uterus undergoes in pregnancy are very remarkable. Gradually enlarging and rising upward against the anterior abdominal wall, it can be felt as a large ovoidal mass extending into the umbilical region; and examination per vaginam shows that the cervix is nearly obliterated. The walls of the uterus lose the compact condition of their texture, and become loose and extensible until the time of birth, when they are extremely thin. There is an increased development of the muscular structure, and the vessels, nerves, and lymphatics increase proportionately in size. In a case of the Cæsarean operation (already referred to, page 5) the author had an opportunity

PLATE 68.

Dissection of the right inguinal region in the male, with especial reference to the anatomy of hernia.

Figure 1.

The skin and the outer layer of the superficial fascia are removed to show the relations of the lymphatic glands above Poupart's ligament and about the saphenous opening of the fascia lata; also the superficial vessels and nerves.

1. The aponeurosis of the external oblique muscle of the abdomen.
2. The arciform fibres, which below constitute the intercolumnar fascia.
3. The epigastric lymphatic glands in relation to Poupart's ligament.
4. The ilio-hypogastric and ilio-inguinal nerves, just above Poupart's ligament.
5. The superficial epigastric artery and vein.
6. The external cutaneous nerve of the thigh.
7. The external pillar of the superficial abdominal opening (or ring).
8. The femoral lymphatic glands.
9. The scrotal lymphatic glands.
10. The anterior cutaneous nerve.
11. The internal cutaneous nerve.
12. The internal saphenous vein.
13. The cutaneous branches of the genito-crural nerve.
14. The internal pillar of the superficial abdominal opening (or ring).
15. The dorsal veins of the penis.
16. The right testicle, with a small reducible hernia in relation to the spermatic cord, covered with the prolongation of the intercolumnar or external spermatic fascia.
17. The penis.

Figure 2.

The lymphatic glands are removed with the cribriform fascia, and the testicle is drawn upward to show plainly the superficial abdominal opening, and the femoral opening below Poupart's ligament.

1. The external oblique muscle of the abdomen.
2. The right testicle drawn upward.
3. Branch of the superficial circumflex iliac artery.
4. The arciform fibres.
5. The anterior superior spinous process of the ilium.
6. The femoral artery.
7. The femoral vein.
8. The external cutaneous nerve of the thigh.
9. The anterior cutaneous nerve.
10. The anterior crural vein.
11. The internal cutaneous nerve.
12. The internal saphenous vein.
13. The fascia of the external oblique muscle, covering the rectus muscle.
14. The cremasteric artery and vein.
15. The superficial abdominal opening or ring.
16. The femoral opening or ring.
17. The superficial dorsal vein of the penis.

Figure 3.

The lower portion of the external oblique muscle is detached and reflected upon the abdomen.

1. The internal oblique muscle of the abdomen.
2. The deep circumflex iliac artery.
3. The ilio-hypogastric nerve.
4. The ilio-inguinal nerve.
5. The anterior superior spinous process of the ilium.
6. The cremaster muscle and fascia.
7. The genital branch of the genito-crural nerve.
8. The right testicle, with its coverings, except the dartos.
9. The under surface of the external oblique muscle.
10. The supra-pubic fatty tissue, and the suspensory ligament of the penis.
11. The insertion of the tendon of the internal oblique muscle.
12. The dorsal veins of the penis.
13. The penis.

Figure 4.

The lower portions of the external and internal oblique muscles of the abdomen are detached and reflected.

1. The transversalis muscle of the abdomen.
2. The deep circumflex iliac artery.
3. A perforating branch of the deep epigastric artery.
4. The anterior superior spinous process of the ilium.
5. The cremaster muscle.
6. The right testicle.
7. The internal oblique muscle reflected.
8. The external oblique muscle reflected.
9. The conjoined tendon of the internal oblique and transversalis muscles.
10. The dorsal veins of the penis.
11. The penis.

Plate 68

Fig 1

Fig 2

Vol II

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Dissected, Photographed and Colored from Nature by George McClellan, M.D.

Armstrong & Co. Lith. Boston

of *seeing* some of these changes. Upon opening the abdomen, the uterine wall appeared tense, glistening, and translucent, and so thin that it could be compared only to parchment stretched over the child, which could be readily distinguished. The broad ligaments were not noticeable, owing to the expansion of the uterus, but the round ligaments appeared like broad flat bands, greatly enlarged. Everywhere upon the surface there were large branching veins. The small intestines were crowded backward out of sight.

After parturition the uterus returns in a very short time to nearly its usual size. Its cavity always continues larger than it was originally, and the os externum assumes a transverse direction, being more marked and often fissured. After the menopause has been completed the uterus slowly and gradually atrophies, and in very old age the neck appears obtuse and rounded and both the internal os and the external os are occluded.

The Fallopian tubes have already been described as they appear in position (page 113). They are ten centimetres, or about four inches, in length, and when removed with the uterus (Plate 65, Fig. 1, Nos. 3 and 13) and floated in water the fimbriæ can be separated and a probe passed into the ostium abdominale and along the tubular canal. This is at first tortuous and dilated into an ampulla, but soon becomes straight, and at the uterine extremity opens by a minute orifice into the upper angle of the cavity of the uterus. The lumen of the canal is about three millimetres, or one-eighth of an inch, in diameter at the abdominal opening, and one millimetre, or one-twenty-sixth of an inch, in diameter at the uterine opening. The structure of the Fallopian tubes is, besides the peritoneal coat, composed of longitudinal and circular plain muscle-fibres, continuous with those of the uterus, and a mucous lining folded longitudinally, so as to give it a stellate appearance upon section, and covered with ciliated columnar epithelium. Commonly there are several stalked cysts (the *hydatids of Morgagni*) projecting at the fimbriated extremity. The mucous membrane lining the canal comes directly into communication with the serous membrane of the abdominal cavity,—which is interesting because it is the only instance of these membranes

coming together in the body. The Fallopian tubes are supplied by the ovarian arteries, and their veins join the ovarian veins. The lymphatic vessels and nerves are numerous and accompany the vessels. Ordinarily the fimbriated extremity hangs free from the broad ligament directed downward and backward, with the mouth directed toward the ovary, so that under excitement the fimbriæ, probably acting like little tentacles, receive the ova on their escape from the ovary and convey them into the mouth of the tube.

The ovaries are shaped somewhat like almonds, and are variable in size, being smooth and whitish before the establishment of the menses, but afterward, as life advances, appearing yellowish or brownish in color and irregularly furrowed by the formation of cicatrices from the periodic escape of the ova. They are commonly thirty millimetres, or about an inch and a quarter, in length, seventeen millimetres, or three-quarters of an inch, in width, and twelve millimetres, or half an inch, in thickness. Each ovary consists of a dense, soft, reddish stroma surrounded by a paler-colored layer in which the *ovisacs*, or *Graafian follicles*, are embedded, and therefore called the *ovigenous layer*. Within the ovary there are numerous plexiform vessels interwoven with connective tissue and smooth muscle-fibres (the *zona vasculosa*). The arteries as they penetrate the organ from its free borders between the broad ligament usually take a peculiar wavy or spiral course through the stroma. Upon section of an ovary the *Graafian follicles* appear as transparent vesicles. They contain the ova. They are always smallest and most numerous at the surface, becoming fewer and larger toward the centre. When the larger follicles are matured they approach the surface, and at each menstrual period one (or perhaps several) ruptures and the ovum escapes into the fimbriated end of the Fallopian tube, which conveys it into the uterus. This is accompanied by an increased vascularity about the follicle, so that upon its rupture the empty sac becomes filled with blood, which, undergoing change through an exudation from its wall, of a peculiar reddish-yellow color, is called the *corpus luteum of menstruation*, because it gradually diminishes, and disappears in about two months. If the ovum becomes impregnated, the *corpus luteum of pregnancy* occurs,

being much larger, and having a trace of a cavity in the centre, owing to increased vascularity. It does not disappear before the eighth month. Remains of the follicles are often found in the deeper part of the stroma in various stages of atrophy and degeneration, showing that they do not always arrive at maturity, but sometimes pursue a retrograde course and disappear. It has been estimated that in the ovary of a young maiden there were as many as thirty-six thousand Graafian follicles (Henle). They are either spherical or oblong. The microscope shows that the larger follicles are provided with a basement membrane,—the *membrana propria*, —surrounding a distinct cell-wall. Lining the wall there is a layer of nucleated cells, called the *membrana granulosa*, which as it approaches the surface of the ovary is thickened at one part (the *discus proligerus*), containing a nucleated cell, the *ovum*, floating within a drop of transparent albuminous fluid, the *liquor folliculi*.

The *ovarian artery* (Plate 65, Fig. 1, No. 6) arises from the abdominal aorta below the renal artery, and is analogous to the spermatic artery. It enters the broad ligament and runs parallel and close to the Fallopian tube, which it supplies, and sends large branches to the fundus of the uterus. Upon reaching the ovary the proper branches run spirally in parallel lines, in the same way that the arteries in the testicle do (page 149). The *ovarian veins* form a *plexus venæ pampiniformi*, and terminate like the spermatic veins, the right passing to the inferior vena cava, and the left to the left renal vein. The *ovarian plexus of nerves* is derived from the renal plexus.

The viscera of the male pelvis (Plates 74 and 75) are the *bladder* in front, with the prostate gland about its neck and the vesiculæ seminales and vasa deferentia at its base, and the *rectum* behind, adapting itself to the anterior curvature of the sacrum and coccyx. The *reflections of the peritoneum* from the anterior wall of the abdomen to the summit of the bladder and thence over its posterior surface and on to the rectum have already been described (page 31). The pouch between the bladder and the rectum, the *recto-vesical pouch*, is of peculiar interest as to the depth to which it reaches in relation to the surface of the perineum in the male. It ordinarily does not extend to within

from seventy-five to one hundred millimetres, or from three to four inches, of the anus, but it sometimes is within five centimetres, or two inches, being in direct contact with the prostate gland, as the author found in two of the dissections for this volume. In children, owing to the bladder being placed comparatively higher (page 131), the peritoneum descends relatively lower than it does in the adult. The reflections of the peritoneum which constitute the *false ligaments of the bladder* should be examined before the membrane is removed, and while that organ is in position. The *superior ligament* is the fold covering the urachus and the obliterated hypogastric arteries (Plate 56), and extends from the anterior wall of the abdomen near the umbilicus to the summit of the bladder. The two *lateral ligaments*, right and left, pass to the sides of the organ from the sides of the pelvis. The two *posterior ligaments* are formed by the lateral borders of the recto-vesical pouch. They respectively enclose the right and left ureters, some vessels and nerves, and the hypogastric cords. The *true ligaments of the bladder* are formed by the expansions of the fascia lining the pelvic cavity, and are of the greatest importance, as they serve to maintain the position of the neck of the bladder.

The pelvic fascia is a thin, strong membrane which lines the wall of the pelvic cavity, being directly continuous with the extra-peritoneal fascia in front (page 17) and with the iliac or ilio-psoas fascia (page 69) at the sides. It arises from the attachment of these fasciæ on either side at the posterior surface of the pubes and the contiguous portion of the brim of the pelvis and from the bone just above the attachment of the obturator internus muscle, where in relation to the obturator canal it arches beneath the obturator vessels and nerve (Plate 76, Fig. 1, No. 17). At the posterior border of the obturator internus muscle it continues as a much thinner layer over the pyriformis and coccygeus muscles and the sacral plexus of nerves, behind the internal iliac vessels, to the front of the sacrum. It descends upon the pelvic wall until it receives the tendinous attachment of the middle portion of the levator ani muscle (page 167), which forms a dense, *curved, white line* extending from the symphysis pubis to the spine of the ischium.

This line is an important landmark, as it indicates the position of the separation of the pelvic fascia proper into two layers, the inner layer becoming the recto-vesical fascia and the outer layer becoming the obturator fascia.

The *recto-vesical fascia,* or *visceral layer of the pelvic fascia* (Plate 74, Fig. 2, No. 13), descends over the pelvic surface of the levator ani muscle and is attached to the lower portions of the viscera,—viz., in the male the bladder, the prostate gland, and the rectum, and in the female the bladder, the vagina with the neck of the uterus, and the rectum. These expansions constitute the various *true ligaments of the pelvic viscera,* so called because they serve to support these organs and in a measure to maintain them in their proper positions.

The *obturator fascia* descends on the inner surface of the obturator internus muscle, forming the sheath for the internal pudic vessels and nerve (page 155), and is attached to the pubic arch, to the tuberosity of the ischium, and to the border of the great sacro-sciatic ligament. Anteriorly it stretches across between the rami of the pubes, being continuous with the similar fascia from the opposite side, and forms the *sub-pubic fascia,* or *posterior layer of the triangular ligament* (page 166). This layer also sends a thin expansion over the perineal surface of the levator ani muscle, called the *ischio-rectal* or *anal fascia* (page 167). It will thus be seen that the levator ani muscle is ensheathed by the two layers of the pelvic fascia which originate at its insertion, and the white line which it occasions therefore further marks the boundary-line between the pelvis and the region of the perineum,—the *floor of the pelvis* being formed by the pyriformis muscle, the sacro-sciatic ligaments, the coccygeus muscle, and the levator ani muscle upon both sides, and the sub-pubic fascia.

It is no easy task to dissect out the various reflections of the pelvic fascia, for the pelvic viscera are so surrounded by venous plexuses (page 128) embedded in the meshes of the loose areolar tissue between the fascia and the peritoneum that their limitations are very perplexing. In fact, the definiteness usually ascribed to the layers of this fascia in the adult may be held to be the handiwork of the dissector. It is

hoped, however, that the many views of the regions of the pelvis and of the perineum contained in this volume will help to convey an impression of the most important relations of this fascia. These are especially referred to with the description of the viscera with which they are in contact, but it may be observed here that the general design of the fascia is to support the viscera upon the floor of the pelvis and to place a barrier between it and the perineum. If from any cause the *recto-vesical layer* becomes relaxed, prolapsus of the bowel or of the uterus is liable to occur. In certain localities the fascia and the peritoneum come very close together. This is particularly the case in the recess between the rectum and the bladder in the male or between the rectum and the uterus in the female, where the recto-vesical or recto-uterine pouch of the peritoneum reaches generally within nine centimetres, or three and a half inches, of the anus, and in some cases considerably lower. The connective tissue is everywhere continuous, but is most abundant between the anterior wall of the bladder and the pelvis, about the base and neck of the bladder, and between the bladder and the rectum, and in the female about the neck of the uterus and the commencement of the vagina and between the layers of the broad ligament. Inflammation in any part of this tissue (*pelvic cellulitis*) resulting in an abscess very often affords a practical demonstration of the double *rôle* which the pelvic fascia plays. For when suppuration occurs above the recto-vesical layer it will be found to be limited to the pelvic cavity, while if it occurs below it it is circumscribed within either the urethral triangle or the ischio-rectal portion of the perineum. Moreover, if the abscess is above the barrier the pus will well up from the pelvis and point usually in the groin, following the course of continuity of structure. It is interesting to note that all the blood-vessels of the pelvis, with the exception of the *obturator*, are between the peritoneum and the pelvic fascia, and that where they pierce the membrane to leave the pelvis the openings are usually reinforced by additional fibrous bands.

The *vesico-prostatic* (Plate 74, Fig. 1, No. 11) and *vesico-uterine* (Plate 72, Fig. 3, No. 23) *plexuses of veins* are deserving of careful

attention. These plexuses are formed of very large veins which freely intercommunicate about the neck and base of the bladder and the prostate gland in the male or about the neck of the bladder and the vagina in the female. They receive the blood returning from the external genital organs by the veins which pierce the sub-pubic fascia and communicate behind with the inferior hæmorrhoidal plexus. They empty into the internal iliac veins. During childhood these venous plexuses are not especially large, but in advanced life they are liable to become enormously distended and varicosed, and frequently contain concretions, called *phleboliths*. All the *nerves within the pelvis* are placed outside of the pelvic fascia, so that they are separated from the vessels, with the exception of the obturator nerve, which accompanies the obturator vessels.

The urinary bladder in the male if viewed from above when moderately distended (Plates 56 and 61) appears like a globular pouch placed between the pubes and the rectum. Its shape and relations are influenced chiefly by the degree of its distention. When emptied in the natural state it shrinks into the floor of the pelvic cavity and is pressed upon by the overlying small intestine, so that upon antero-posterior section the cavity appears triangular, with the base in relation to the rectum and the apex toward the symphysis pubis. As the urine accumulates, the organ gradually assumes an ovoidal form and the summit rises above the symphysis of the pubes (Plate 74), and in cases of extreme distention it may even reach as high as the umbilicus. As the peritoneum is lifted from the anterior wall of the abdomen when the bladder is fully distended, this region is sometimes selected for tapping the bladder or for supra-pubic lithotomy. There is always a considerable amount of loose connective tissue behind the symphysis of the pubes, which permits the bladder to alter its dimensions; but care should be exercised in the above operations not to allow the urine to escape into the meshes of this tissue, as it is peculiarly liable to diffuse inflammation.

In the fœtus at six months (Plate 26, Fig. 2, Vol. I.) and in the infant (Plate 66, Fig. 3, No. 2) the bladder is situated mainly in the abdomen, the pelvis being small and shallow, and it is narrowed at

PLATE 69.

Dissection of the right inguinal region in the male, with especial reference to the anatomy of hernia.
(Continuation of Plate 68.)

Figure 1.

The lower portions of all the abdominal muscles are reflected to show the extra-peritoneal fascia, the relations of the deep epigastric artery, and the position of the deep abdominal opening.

1. The extra-peritoneal fascia.
2. The deep circumflex iliac artery and veins.
3. The deep epigastric artery and veins.
4. The position of the deep abdominal opening.
5. The infundibuliform process of the extra-peritoneal fascia.
6. The anterior superior spinous process of the ilium.
7. The cremaster muscle and fascia.
8. The right testicle.
9. The reflected portion of the external oblique muscle.
10. The reflected portion of the transversalis muscle.
11. The reflected portion of the internal oblique muscle.
12. The suspensory ligament of the penis.
13. The penis.

Figure 2.

The extra-peritoneal fascia is divided and held aside to show the fatty tissue in relation to the deep abdominal opening. The peritoneal sac is also seen prolonged over the spermatic cord.

1. The peritoneum.
2. The extra-peritoneal fascia drawn outward.
3. The prolongation of the peritoneal sac.
4. The femoral artery.
5. The cremaster muscle and fascia.
6. The reflected transversalis muscle.
7. The extra-peritoneal fascia drawn aside.
8. The reflected internal oblique muscle.
9. The reflected external oblique muscle.
10. The suspensory ligament of the penis.
11. The penis.

Figure 3.

The peritoneum is slit open to show the coil of the ileum, which is partially reduced to demonstrate the character of the sac in the ordinary form of inguinal hernia.

1. The ileum.
2. The right portion of the peritoneal sac.
3. The right portion of the detached extra-peritoneal fascia.
4. A portion of the omentum protruding from behind the intestine.
5. The thin fibrous band which is generally found along the front of the cord and is the remains of the early fœtal pouch of the peritoneum.
6. The termination of the fibrous band at the upper portion of the tunica vaginalis testis.
7. The right testicle.
8. The reflected internal oblique muscle.
9. The reflected transversalis muscle.
10. The left portion of the peritoneal sac.
11. The left portion of the detached extra-peritoneal fascia.
12. The reflected external oblique muscle.
13. The suspensory ligament of the penis.
14. The penis.

Figure 4.

The dissection of the abdominal wall is extended upward, and the peritoneum freely divided. The caput cæcum coli is drawn forward and outward so as to display the vermiform appendix (in this case) *descending* into the iliac fossa.

1. The cæcum.
2. The vermiform appendix.
3. The right portion of the peritoneal sac.
4. The right portion of the detached extra-peritoneal fascia.
5. The fibrous band in front of the spermatic cord.
6. The position of the upper end of the tunica vaginalis.
7. The right testicle.
8. The reflected internal oblique muscle.
9. The reflected transversalis muscle.
10. The ileum.
11. The left portion of the detached extra-peritoneal fascia.
12. The left portion of the peritoneal sac.
13. The reflected portion of the external oblique muscle.
14. The suspensory ligament of the penis.

N.B.—The dissections shown in Plates 68 and 69 were taken from the body of a man who had a small reducible inguinal hernia, and the parts are shown exactly as they were exposed.

Plate 69 Vol. II

Fig 1

Fig 2

B

C

Dissected Photographed and Colored from Nature by George McClellan M.D.

Armstrong & Co. Lith. Boston.

the upper part by the hypogastric arteries, which converge toward the umbilicus. There is no marked fundus or base to the bladder in early life, but as the pelvic cavity increases in size the bladder gradually descends into it, and as the child begins to sit and walk the weight of the urine probably tends to make the lower part more capacious. Throughout childhood until puberty, when the organs of generation are fully developed and the neighboring parts assume their normal adult relations, the bladder is always so loosely attached to the pelvic walls that, although it may have settled in the pelvis, it will require very little force to push it upward into the abdomen. This lax condition of the attachments of the bladder is of great importance in the consideration of surgical interference in this region. It should be remembered that the anterior abdominal wall in the young child from the pubes almost to the umbilicus is in close relation to the bladder, and that the neck of the bladder and urethral orifice is about on a level with the upper border of the pubic symphysis. In the adult the position of the neck of the bladder is three centimetres, or about one and a quarter inches, behind and a little below the centre of the pubic symphysis, while standing, but when lying upon the back it is lower by twelve millimetres, or half an inch.

The ligaments of the bladder, which are formed by the reflections of the peritoneum and the expansions of the pelvic fascia, have already been described (page 126). They serve to maintain the neck of the organ in its proper position. The average capacity of the bladder is about one pint, but it varies considerably, even in health, depending very much upon the habits of the individual. When distended, the upper part is called the *summit,* and the lower part the *base,* or *fundus.* The latter extends forward and downward into a funnel-shaped portion, the *neck,* which is embraced by the prostate gland and terminates in the urinary passage, or *urethra.* These can be best seen when the parts are laid open, as in Plate 75, Figs. 1 and 2.

The *walls of the bladder* are in a measure proportioned in thickness to the degree of expansion of the organ, being twelve millimetres, or about half an inch, in the collapsed state, and thinning out to two

millimetres, or a line, when fully distended. Besides the partial investment of the peritoneum over the summit and back, the structure of the walls consists of the muscular coat and the lining mucous membrane.

The *muscular coat* is covered externally with a thin fibro-connective-tissue layer, derived chiefly from the recto-vesical fascia, which contains most of the larger vesical arteries and veins, the former ramifying over it and the latter beneath it. There are three incomplete strata of unstriped muscular fibres. The outer layer consists of reddish longitudinal fibres, which are most conspicuous in front and behind,—some passing downward from the summit, and called the *uracho-vesical fibres*, intersecting with others which radiate from the attachment of the pelvic fascia in front, and called the *pubo-prostatico-vesical fibres;* while others, variably developed, pass from the recto-vesical fascia, embrace the neck of the bladder, and, interweaving with one another around the terminations of the ureters, are called the *recto-vesical fibres*. These series of fibres interlace freely with one another, and, owing to their combined function, are sometimes collectively named the *detrusor urinæ muscle*. The middle layer is composed mostly of circular or oblique fibres, which are especially pronounced about the neck and commencement of the urethra, where they form the *sphincter vesicæ*. The fibres composing the innermost layer are feebly developed, except about the orifices of the ureters, where they sometimes become hypertrophied and cause projections into the cavity of the bladder at these localities. They are the *musculi pylori* of the ureters (or *Bell's muscles*).

The *mucous membrane of the bladder* is usually of a grayish color, very soft and smooth, and is closely but loosely attached by the elastic submucosa to the muscular coat, so that when the organ is contracted it becomes wrinkled. It is provided with very few mucous glands, and its epithelium is continuous with that of the ureters. When the bladder is opened and examined from above (Plate 75, Fig. 2), there is a slight triangular prominence between the orifices of the ureters behind and the orifice of the urethra in front,—the *trigonum vesicæ*, or *vesical triangle*. It is paler than the rest of the mucous membrane, and without any rugæ. The orifices of the ureters are fifty millimetres, or about

two inches, apart, and thirty-five millimetres, or about an inch and a half, behind the vesical urethral orifice. The lateral boundaries of the trigonum are formed by two slight ridges extending forward from the ureters, and look not unlike continuations of them. They are due to the elevation of the muscular fibres of the innermost layer above mentioned. In addition to these there is a ridge (the *bar of Mercier*) extending transversely behind the orifices of the ureters, which in old age becomes prominent in consequence of the formation of a pouch behind the prostate gland. The *ureters* have been described in connection with the kidneys (page 65). They pass obliquely through the walls of the bladder and run for some little distance before they terminate at the angles of the trigonum, and this obliquity, aided possibly by the action of the internal layer of muscular fibres, prevents the urine from returning into the ureters. The *vesical orifice of the urethra* is situated at the lower and anterior part of the neck of the bladder. The apex of the trigonum, which projects upward into it, is more or less noticeable in different bladders, and is called the *uvula vesicæ.* The trigonum corresponds to the space between the vesiculæ seminales and above the prostate gland on the external surface of the base of the bladder, where it rests upon the rectum and is usually uncovered with peritoneum. Through this space the bladder may be tapped for retention of urine.

The *arteries of the bladder* are the *superior vesical,* which is the unobliterated portion of the hypogastric artery (page 17), the *middle vesical,* from the above, or independently from the internal iliac artery (Plate 76, Fig. 1, No. 13), and the *inferior vesical,* which arises usually from the pudic artery. The obturator and sciatic arteries also contribute small vesical branches. The *veins of the bladder* form large vesicoprostatic plexuses about the neck and base of the bladder (page 128) (Plate 74). The *nerves* are derived from the hypogastric plexus, which forms a close net-work in the mucous membrane, and the vesical branches of the second and third sacral nerves, which form a plexus among the fibres of the muscular coat. The *lymphatics* are comparatively very few, and are found upon the anterior wall and the trigonum. They

accompany the veins and terminate in the inferior hypogastric lymphatic glands in relation to the internal iliac veins (page 157).

The prostate gland is a firm musculo-glandular mass situated at the neck of the bladder and surrounding the first part of the urethra (Plate 74, Fig. 2, No. 12, and Plate 75, Fig. 1, No. 14, and Fig. 2, No. 7). In the adult it is ordinarily about the size and shape of a large chestnut, but it is variable, and commonly enlarges after sixty years of age. Its narrow end (the *apex*) is directed downward and forward as far as the sub-pubic fascia, while the posterior and larger portion (the *base*) is in close relation with the rectum, through which it can be readily felt by the finger, when the bladder is partially distended, six centimetres, or about two and a half inches, above the anus. It is surrounded by the vesico-prostatic plexus of veins (page 128), and is held in position by the pelvic fascia (page 126) and by the levator ani muscles anteriorly (Plate 78, Fig. 2, No. 4). Normally the prostate measures transversely at the base thirty-five millimetres, or about an inch and a half, and vertically in the direction of the urethra twenty-six millimetres, or about an inch. To external appearance the prostate is one convex mass, but upon dissection it presents a *lateral portion* or *lobe* on each side of the base, and a middle portion included between the ejaculatory ducts and the neck of the bladder, the *isthmus*, or *middle lobe*. The latter corresponds to the position of the uvula upon the vesical surface, and when enlarged in old age or by disease often offers an obstruction to the flow of the urine through the vesical orifice of the urethra. It should be understood, however, that this so-called middle lobe is ordinarily merely a connecting band between the lateral portions, and can properly be called a lobe only when it is hypertrophied. The prostate is ensheathed by an expansion of the recto-vesical fascia, which contains the proper prostatic veins as well as the branches from the dorsal veins of the penis. In cases of hypertrophy of the glandular mass this capsule becomes thickened, and it is then possible to dissect it off and expose the substance of the organ. The unyielding nature of the capsule also serves to explain the severe pain in abscess of the prostate.

The prostate consists principally of a mesh of unstriped muscle-

fibres continuous with the layers of the vesical wall, enclosing numerous small racemose glands which are congregated mostly in the posterior part. The muscle-fibres in front of the prostate are circularly disposed about the vesical orifice of the urethra, and assist in forming the *vesical sphincter*, already mentioned (page 132). In this relation it is sometimes called the *internal prostatic sphincter*, to distinguish it from the *external prostatic sphincter*, the fibres of which are continuous with the membranous part of the urethra.

The *arteries* to the prostate are relatively small, and are derived from the vesical, inferior hæmorrhoidal, and pudic arteries. The *veins* are large and form the prostatic plexuses at the sides. The *nerves* are from the hypogastric plexus of the sympathetic system, and a few medullated fibres possessing Pacinian corpuscles are found on the surface of the organ. The lymphatics are numerous and large, and terminate in a lymphatic gland near the internal iliac vein. The *prostatic glands* are very abundant, constituting the chief bulk of the whole mass. They consist of a series of tubular alveoli which open into elongated excretory ducts lined with columnar epithelium. They are connected with one another by fibrous expansions from the external capsule, and surrounded by muscular tissue. The excretory ducts are arranged in sets corresponding to the lateral lobes and to the middle lobe if it exists, and open into that part of the prostatic portion of the urethra which is called the prostatic sinus (Plate 75, Fig. 2, No. 8). The prostatic fluid (*liquor prostaticus*) is a peculiar viscid secretion, much resembling an emulsion of gum arabic in water.

The male urethra is the canal which extends from the neck of the bladder to the meatus urinarius at the end of the penis. It is twenty centimetres, or about eight inches, in length in the adult, and is divided into three portions, according to the structures through which it passes (Plate 75, Figs. 1 and 2). The first is the *prostatic portion*, which measures in length three centimetres, or one and a quarter inches; the second is the *membranous portion*, which passes between the layers of the triangular ligament beneath the pubic arch, and measures in length two centimetres, or three-fourths of an inch; and the third is

the *spongy portion*, which is contained within the corpus spongiosum of the penis, and is fifteen centimetres, or about six inches, in length.

The *prostatic portion of the urethra* is the widest and the most dilatable part. It is nearer to the upper than to the lower surface of the prostate, and upon transverse section appears crescentic, with the convexity upward. Upon the middle of the floor there is an elevation two centimetres, or three-fourths of an inch, in length, which is broad and prominent behind but diminishes anteriorly, and is called the *colliculus seminalis*, or the *veru montanum*, or the *caput gallinaginis*, from its fancied resemblance to the head of a woodcock. Immediately in front of this, and extending into its base medially, is the *sinus prostaticus*, or *sinus pocularis*, which is one centimetre, or about three-eighths of an inch, in depth, and two millimetres, or a line, in width, at its orifice, and about double that at its base. This little pouch is often found to be prolonged into the lateral lobes of the prostate, and it has therefore been considered to be homologous to the uterus, and is also called the *utriculus*, or *uterus masculinus*. The prostatic ducts open into the depressions upon each side of the sinus, and the apertures of the *ejaculatory ducts* are upon each side of its orifice. The mucous lining is provided with squamous epithelium, and the muscular coat consists of both longitudinal and circular fibres.

The *membranous portion of the urethra* is the narrowest part of the entire canal, and is situated between the two layers of the triangular ligament two and a half centimetres, or about an inch, below the symphysis pubis, being separated from it by the dorsal vessels and nerves of the penis, with some connective and muscular tissue. This portion of the urethra is lined with stratified columnar epithelium, and is encroached upon below by the bulb of the spongy portion so that its floor measures twelve millimetres, or about half an inch. Upon transverse section the canal is circular, but owing to the folding of the mucous membrane the lumen is stellate. When distended, its diameter is five millimetres, or about a quarter of an inch. It is surrounded by the *compressor urethræ muscle*, and Cowper's glands are below upon either side of it.

The *spongy* (or *penile*) *portion of the urethra* is contained within the erectile tissue of the corpus spongiosum (page 142), which commences posteriorly as the *bulb* and terminates in the *glans penis* anteriorly. The external orifice of the urethra is called the *meatus urinarius:* it is bounded by slightly prominent margins or *lips,* and is the most contracted part of the urethra, while the part which is within the bulb, the *bulbous portion of the urethra,* is, next to the prostatic portion, the most dilatable. Within the glans penis the urethra enlarges into a sinus, the *fossa navicularis* (Plate 75, Figs. 1 and 2). Transverse sections through different parts of the spongy portion show that the canal is transverse in the bulbous part, crescent-shaped in the middle (Plate 75, Fig. 3, No. 8), and vertical at the meatus. The orifices of the ducts of the *sub-urethral glands* (*Cowper's glands*) open into the bulbous part. These are two whitish little bodies, about the size of peas, between the layers of the triangular ligament, close to the bulbous portion (Plate 78, Fig. 1, No. 6), and covered by the compressor urethræ muscle. They are racemose mucous glands of quite firm consistence, and are usually lobulated. There are also a number of little pockets, or *lacunæ,* the openings of small glands situated in the submucous tissue, called the *glands of Littré.* Most of the lacunæ are found upon the floor of the urethra, but there is a large one, the *lacuna magna,* on the upper surface, four centimetres, or about an inch and a half, from the meatus. These orifices are directed forward, so that they may be readily entered by filiform bougies, which should never be used without due consideration of their location. When the spongy portion of the urethra is closed, the mucous membrane is folded into fine longitudinal rugæ. It contains a considerable amount of elastic tissue. The outer wall of the urethra is formed by the structure of the corpus spongiosum (page 142) of the penis, through which it passes.

The male urethra may be considered to be formed of a fixed part and a movable part. The *fixed part* extends from the neck of the bladder to the anterior layer of the triangular ligament, and describes a short curve upward beneath the arch of the pubes and two and a half centimetres, or about an inch, below it. The *movable part* consists of

PLATE 70.

Figure 1.

Dissection of the inguinal region in the male. The skin and superficial fascia are removed on the right side to show the cluster of inguinal glands, and on the left side the cribriform fascia is removed to show the saphenous opening.

1. The aponeurosis of the external oblique muscle of the abdomen.
2. The right superficial circumflex artery.
3. The right superficial circumflex vein.
4. The ilio-inguinal nerve.
5. The right superficial epigastric vein.
6. The right superficial epigastric artery.
7. The right external cutaneous nerve.
8. The cluster of superficial lymphatic glands enlarged over the saphenous opening.
9. The middle cutaneous nerve.
10. The anterior crural vein.
11. The right internal saphenous vein.
12. Cutaneous branches of the genito-crural nerve.
13. Aponeurosis of the external oblique muscle.
14. The left superficial epigastric artery.
15. The left superficial circumflex iliac artery.
16. The superior external pudic artery.
17. The iliac portion of the fascia lata.
18. The left femoral artery.
19. The left external cutaneous nerve.
20. The left femoral vein.
21. The left superficial circumflex iliac vein.
22. The inferior external pudic artery.
23. The pubic portion of the fascia lata.
24. The margin of the falciform process of the saphenous opening (Hey's femoral ligament).
25. The left internal cutaneous nerve.
26. The left middle cutaneous nerve.
27. The fascia lata.
28. The left internal saphenous vein.

Figure 2.

The pelvic viscera in a female aged twenty-five years, showing perfectly normal relations, as seen from above.

1. The cæcum distended.
2. The right Fallopian tube and ovary.
3. The right broad ligament.
4. The right round ligament.
5. Appendicæ epiploicæ.
6. The sigmoid flexure of the colon.
7. The commencement of the rectum.
8. The iliac fascia.
9. The fundus of the uterus anteflexed upon the bladder.
10. The left Fallopian tube and ovary.
11. The left round ligament.
12. The bladder partially distended.
13. The anterior wall of the abdomen over the pubic symphysis.

Fig. 1

2

Fig. 2

2

4

2

3

... figured and ... from nature, George McClellan, M.D.

the penile portion of the urethra, which, when the penis is flaccid and dependent, forms a second curve downward. When the organ is erect or in the ordinary position for the introduction of a sound or catheter the second curve is obliterated, and the passage is straight as far as the anterior layer of the triangular ligament, where the first curve begins (Plate 75, Fig. 1). In the well-formed adult the penile urethra is nine millimetres, or about three-eighths of an inch, in calibre. The anatomy of the different portions as above described teaches that in passing any instrument along the urethra pressure against the wall of the spongy or movable portion must be avoided on account of the various lacunæ, and that as soon as the fixed portion is reached the handle of the instrument should be kept strictly in the middle line of the body and then depressed between the thighs, in order that the point of the instrument shall enter and follow the natural curve into the bladder. The anterior layer of the triangular ligament is really a little back of the point of junction of the movable and fixed parts, and, as it is usually the place where some difficulty is experienced in catheterism, it should be remembered that the membranous portion of the urethra is the narrowest part of the canal, and is enclosed by the compressor urethræ muscle and therefore liable to meet with resistance from muscular spasm. In children, owing to the comparative smallness of the prostate, the membranous portion of the urethra is relatively longer. In old men, in whom the prostate is uniformly enlarged, the length of that part of the canal is increased, and if the enlargement is confined to one of the lateral lobes the direction of the canal will naturally deviate to one side or the other. If the middle lobe is enlarged, it will more or less obstruct the passage. The greatest danger in passing instruments along the delicate urethral canal is that of making a *false passage*, which usually happens when no organic stricture exists in front of the triangular ligament. Except in the hands of the experienced, very small sized instruments should be avoided. Many years of hospital practice have impressed upon the author how little this is appreciated, and he does not hesitate to say that *filiform bougies* are responsible for nine-tenths of the mortality of the cases in which they are used. If

there is any obstacle in the region of the prostate, the finger of one hand introduced into the rectum (page 152) will often assist the other in guiding the instrument in the proper course. The most common seat of organic stricture of the urethra is the bulbous part of the spongy portion, because the submucosa is here very extensible and predisposed to exudation when inflamed.

The penis, the organ of copulation, consists of three cylindrical bodies of erectile structure, the *corpus spongiosum urethræ*, below and resting against a groove on the under surface of and between the *corpora cavernosa* above, the whole being ensheathed by a peculiarly thin and extensible skin which is continued from the pubes and the scrotum. It is attached to the borders of the pubic arch by the two crura of the corpora cavernosa (Plate 77, Fig. 2, Nos. 4 and 15), which constitute the *root* of the organ; the free expanded extremity is called the *glans* or *head of the penis*, and the intermediate portion the *body*. The *dorsum* is the upper surface of the corpora cavernosa, and it is attached to the symphysis pubis by the strong elastic *suspensory ligament of the penis* (Plate 56, No. 10, and Plate 69, Fig. 1, No. 12). When the organ is expanded it appears as a rounded three-sided column, surmounted by the glans, which is shaped like a dome with a rounded summit and a broad base. The prominent posterior border of the glans is called the *corona glandis*, and at its base, where it is connected with the body, is the constricted portion termed the *neck*.

The *skin* of the penis is dark-colored, free from fat, and so thin that the subjacent vessels can be readily distinguished. At the extremity it forms the loose and movable *prepuce*, or *foreskin*, by doubling upon itself so as to enclose and protect the glans. The thin fold which connects the under surface of the glans and the lower part of the meatus with the prepuce is named the *frænum præputii*. The skin is modified over the glans by the absence of a proper subcutaneous tissue, and is firmly attached to the underlying structure, becoming continuous with the mucous membrane at the meatus. It is here furnished with numerous vascular and sensitive papillæ. Reflected upon the neck it is provided with many minute sebaceous glands, the *glandulæ odoriferæ* (*of Tyson*),

which secrete the smegma præputii. The skin over the dorsum of the penis toward the pubes is provided with hairs which project from whitish sebaceous glands, while below it presents a slightly-marked median *raphê*, which is continuous with that of the scrotum and the perineum.

The *superficial fascia of the penis* consists of connective tissue, with elastic and some unstriped muscle-fibres, and is directly continuous with the dartos tissue of the scrotum, which it closely resembles. It allows of free movement of the skin everywhere except over the glans, where it blends with the firm covering of that part. Between it and the skin are the *superficial vessels of the penis* (Plate 75, Fig. 3), of which the *arteries* are derived from the external pudic arteries, and the companion *veins* join with the deep dorsal vein and send branches to the external pudic vein. The *superficial nerves* are filaments of the ilio-hypogastric nerves.

A transverse section through the middle of the penis (Plate 75, Fig. 3) shows that the three constituent portions are distinct from one another. The *corpora cavernosa* are placed side by side, and, constituting more than two-thirds of the bulk of the organ, chiefly determine its shape when it is distended. They are composed of erectile tissue, and each is enclosed in a strong fibrous capsule of interlacing fibres, which completely surrounds their crura, but where the two bodies are in contact the intervening layers of the capsules are pierced by rows of vertical slits, so that the partition presents the appearance of a fine-toothed comb and is called the *septum pectiniforme*. Trabeculæ are sent inward from the fibrous investment into the substance of the corpora, thus forming a spongy basis of fibrous tissue, the interspaces of which communicate freely with one another and are lined with epithelium. These spaces or *caverns* are largest at the centre and root of the corpora cavernosa, and are empty when the penis is flaccid and pendulant, but when it is distended they are filled with blood. The *arteries* which supply the cavernous bodies are derived from the pudic arteries and the branches of the dorsal arteries of the organ. The *cavernous arteries* penetrate the inner sides of the crura and advance through the erectile tissue near the septum, giving off numerous minute branches which are enclosed in the trabeculæ. The branches from the dorsal arteries penetrate the

fibrous investment near the corona glandis, and are distributed also to the erectile tissue. The arterioles from these sources are called the *helicine arteries*, because some of them, terminating in the capillaries of the cavernous spaces, form loops or tendril-like curls. They open either directly into the cavernous spaces or into the efferent veins. The blood is returned from the corpora cavernosa by venous radicles which commence in the sinuses or caverns and unite to form trunks which mostly pass into the *dorsal vein* and through it into the prostatic venous plexus, while others join the deep veins which leave the root of the organ to empty into the internal pudic veins.

The erect condition of the organ is brought about by the action of the *ischio-cavernosus* and *bulbo-cavernosus muscles* (page 164), which compress the veins below the pubic arch and thus prevent the blood from being conveyed from the cavernous spaces.

The *corpus spongiosum*, which surrounds the urethra (page 135), is composed of erectile tissue similar to that of the corpora cavernosa, except that its capsule and trabeculæ are made up of finer and more elastic fibres and connected with the wall of the urethra instead of a median septum. The spaces are smaller and the *helicine arteries* are most abundant in the bulbous part. It is supplied by the large *bulbar arteries* (Plate 78, Fig. 2, No. 17) and by branches from the pudic arteries. The *veins* from the glans end in the *dorsal vein*, while those from the body and bulbs pass to the pudic veins and the prostatic plexus. There are also communications with the superficial veins of the skin of the penis and the scrotum. The great *dorsal vein* of the penis is contributed to by veins from all parts of the organ. It should be especially noted that it passes beneath the suspensory ligament and through both layers of the triangular ligament. It lies between the two dorsal arteries beneath the fascia on the dorsum (Plate 75, Fig. 3). The *nerves* to the penis are the *pudic nerves* and their superficial perineal branches (page 167). They supply the skin and the mucous membrane. Upon the glans there are numerous Pacinian bodies and nerve-end bulbs. The erectile tissue of the organ is abundantly supplied with filaments from the *hypogastric plexus*, which contain many vaso-dilator

fibres that regulate the dilatation of the arteries. The *lymphatic vessels* consist of superficial and deep sets. The former convey the lymph from the glans and skin of the penis to the inguinal glands (Plate 70, Fig. 1, No. 8). The deep set pass from the erectile portions of the organ through the triangular ligament to the pelvic lymphatic glands. Occasionally a lymphatic gland is placed near the suspensory ligament and is liable to become involved by an ulcer on the prepuce.

The penis is often the seat of malformation from arrest of development; the commonest forms are called *hypospadias* and *epispadias*,—the former being due to deficiency in the floor of the urethral canal and the corresponding part of the corpus spongiosum, while the latter is the condition resulting from a similar deficiency in the roof of the canal and the corresponding parts of the corpora cavernosa. They are usually confined to the neighborhood of the glans penis, but either of them may involve the entire length of the canal.

The scrotum is the pouch of integument which hangs from the pubes at the root of the penis, and contains the testicles and part of the spermatic cord. The skin of the scrotum is very thin, transparent, and extensible. It is of a dark reddish-brown color, and provided with sebaceous glands and scattered crisp hairs which arise from large conspicuous follicles. There is a median *raphê* which continues backward to the perineum, and on each side of it the skin is corrugated into transverse folds or *rugæ*, which are especially noticeable when the individual is vigorous or the parts are exposed to cold. In the aged and enfeebled, or under the relaxing effect of warmth, the scrotum becomes smooth and pendulous. This rugous folding of the skin is due to the action of the peculiar subcutaneous tissue, called the *dartos*, which consists chiefly of a thin layer of longitudinal non-striped muscular fibres with elastic connective tissue wholly without any fat (page 6). The deep layer of the dartos forms a vertical partition, the *septum scroti*, which passes from the raphé to the root of the penis between the testicles, so that each of them occupies a separate compartment, that for the left usually being the longer. The muscular tissue of the dartos is most abundant at the sides and in front, and its peculiar character

accounts for the remarkable contractility of the scrotum. Its elasticity also allows of great distention, as in the various forms of scrotal tumors and anasarca. In fact, this tissue is wonderfully accommodating, for even in cases where large portions are removed by disease or by the knife it would hardly seem to be missed, as the remainder upon healing speedily assumes the proper dimension. This is especially remarkable in view of the fact that the vitality of the scrotum is not considerable, as it is often affected with sloughing and is more frequently than any other part of the body the seat of elephantiasis. The *arteries* which supply the cutaneous structures are the *superficial* and *deep pudic* branches of the femoral artery and the *superficial perineal.* The superficial *nerves* are branches from the ilio-inguinal, the *long pudendal branch* from the small sciatic nerve, and the *perineal nerve.* The lymphatics pass to the inguinal glands.

The peculiar function of the scrotum is to afford protection to the very delicate testicles, which through its great mobility escape injury from contusions, sometimes in the most astonishing way. The author recently saw a young man whose scrotum had been ripped open by the kick of a horse so that both testicles dropped from their pouches, and yet not the least damage had been done to their structure.

Beneath the dartos each testicle, with the adjacent part of the spermatic cord, is invested with the *spermatic fascia,* or *tunica cremasterica* (page 13), which consists of the blending of the intercolumnar (page 85), cremasteric (page 86), and infundibuliform (page 87) fasciæ. They have all been described with the anatomy of the inguinal region with reference to hernia. They cannot be demonstrated as separately distinct coverings of the testicle, except where they are severally hypertrophied, as sometimes happens in old age or in large irreducible herniæ. The manner in which they are believed to be originally prolonged over the testicle at the time of its descent into the scrotum has also been described (page 88), as well as the formation of the prolongation of the peritoneum called the *tunica vaginalis testis* (page 91).

The testicles (*testes*) are the glandular organs which secrete the semen. They are of oval shape, with flattened sides, and measure usually

thirty-five millimetres, or about an inch and a half, in length, twenty-three millimetres, or about an inch, in breadth, and nineteen millimetres, or three-fourths of an inch, in thickness, although they vary greatly in size in different individuals. The left is often larger, and generally hangs lower, than the right. They are suspended by the spermatic cords, which are attached along their posterior borders, so that in the erect position they appear as if obliquely placed, with their upper ends diverging and directed forward and outward. When examined through the scrotal walls, the front and sides of each testicle are smooth and convex, but the posterior border feels convoluted and irregular, owing to the presence of the appendage of the testicle called the *epididymis.* This consists of an upper end, the *globus major,* or head, which is the largest part, the *body,* which curves downward along the back of the testicle, and a lower end, the *globus minor,* or tail. At the top of the testicle and between it and the globus major there are one or two small spheroidal stalked bodies, called the *hydatids of Morgagni,* which are formed by pouchings of the tunica vaginalis. This serous membrane when entirely cut off from the general peritoneum (page 91) forms a closed sac, which is doubled over the testicle and epididymis, so that they are completely invested except at the back of the testicle and the inner border of the epididymis, where they are connected and the vessels and vas deferens are situated. Here the deficiency in the serous membrane is filled by a layer of unstriped muscular tissue called the *inner muscular coat,* which may be a remnant of the gubernaculum testis (page 89). The fold of the vaginal tunic in contact with the gland is called the *visceral layer.* It is closely united with the subjacent fibrous capsule, or *tunica albuginea,* of the testicle, and dips into and lines the fissures of the organ, but over the epididymis it is more loosely attached and forms a narrow pouch, the *digital fossa,* along the outer posterior border of the testicle. The outer or *parietal layer* is wider, and extends upward to a variable distance upon the cord and below the testicle, lining the scrotum. The parietal layer is much the stronger of the two, and is rough and areolar upon its external surface. In the usual condition there is no appreciable separation between the apposed surfaces of the

PLATE 71.

Figure 1.

View of the female pelvis from above, showing the relations of the uterus to the rectum and bladder (distended); also the normal appearance of the uterine appendages.

1. The right psoas magnus muscle.
2. The inferior vena cava.
3. The posterior layer of the peritoneum.
4. The rectum descending into the true pelvis.
5. The right Fallopian tube.
6. The right ovary.
7. The vesico-uterine fold of the peritoneum.
8. The right round ligament.
9. The bladder distended.
10. The right epigastric artery, seen through the anterior peritoneal layer.
11. The abdominal aorta.
12. The termination of the colon.
13. The recto-uterine fold of the peritoneum.
14. The left Fallopian tube.
15. The left ovary.
16. The fundus of the uterus covered with the peritoneum.
17. The left round ligament.
18. The left deep epigastric artery, seen through the peritoneum.
19. The anterior ligament of the bladder.

Figure 2.

The broad ligaments are drawn to the sides of the pelvis and the bladder is emptied, to show the cavities of the true pelvis and the shape of the uterus. (Same pelvis as Figure 1.)

1. The body of the second lumbar vertebra.
2. The right psoas magnus muscle.
3. The inferior vena cava.
4. The posterior layer of the peritoneum.
5. The rectum.
6. The right ovary.
7. The broad ligament on the right side.
8. The right round ligament.
9. The right epigastric artery.
10. The bladder empty.
11. The abdominal aorta.
12. The termination of the colon.
13. The broad ligament on the left side.
14. The fundus of the uterus.
15. The left round ligament.
16. The left epigastric artery.

Fig 1

Fig 2

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sac, which are smooth and polished, and lubricated by the secretion of a small quantity of serous fluid. Although the tunica vaginalis is not of itself very vascular, sometimes this fluid is secreted in excess and accumulates, producing *hydrocele.*

The *tunica albuginea* (Plate 65, Fig. 3, No. 11) is a dense, inelastic membrane composed of interlacing layers of white fibrous tissue. It encapsulates the testicle, and at the back of the gland is projected for a short distance into its substance, forming an incomplete septum, the *corpus Highmorianum,* or *mediastinum testis,* from which delicate diverging expansions, the *trabeculæ testis,* extend across to the inner surface of the capsule, thus separating the glandular substance into lobules. Upon section this substance appears as a yellowish-brown pulpy mass, and the lobules can be distinguished with their bases next the surface of the organ and their apices converging to the mediastinum. These lobules are irregular in size, the central being the largest, and are estimated as usually numbering about one hundred and twenty, although their number varies with the size of the testicle. By careful dissection in water they can be demonstrated to consist of from two to eight convoluted canals, the *tubuli seminiferi.* These average sixty centimetres, or about two feet, in length when unravelled, and appear as long cylindrical threads of uniform diameter (from the one-hundred-and-twentieth to the one-hundred-and-eightieth of an inch). They begin by closely-twisted closed ends, occasionally bifurcating and joining with one another or with their neighbors in adjoining lobules to form loops. They finally terminate toward the apices of the lobules in straight canals, the *vasa* or *tubuli recti,* of which there are about one hundred and sixty. These penetrate the corpus Highmorianum and establish an anastomosing plexus of seminal tubes called the *rete testis.* As these tubules reach the upper part of the rete they converge to form from fifteen to twenty *vasa efferentia,* which upon piercing the tunica albuginea at first take a straight course, and then, becoming convoluted, form a conical mass, the *coni vasculosi,* which collectively constitute the globus major of the epididymis. Each of these when unravelled is from fifteen to eighteen centimetres, or from six to eight inches, in length, and about one-fiftieth

of an inch in diameter. At the globus major the tubes terminate in the single canal of the epididymis, which is convoluted in the most complex manner, and, being held together by fibrous and areolar tissue, appears as a solid mass four centimetres, or about an inch and a half, in length. When this is unravelled, it will be found to be a single tube six metres, or some twenty feet, in length. As it approaches the globus minor its coats become thicker, while its lumen diminishes, and finally it turns upward and is known as the *vas deferens,* or *spermatic duct,* which, although much twisted at first while under cover of the *inner muscular coat,* becomes straight above the testicle, whence it passes in the cord to the groin. Near the origin of the vas deferens there is a short cæcal tube, the *vas aberrans,* which is convoluted into a little oblong lobe beside the globus minor. When unravelled, it measures usually three centimetres, or an inch and a quarter, in length, although it often exceeds this fourfold.

The microscope shows that the tubuli seminiferi are provided with a thick epithelium consisting of strata (not always defined) of *seminal cells.* The stratum lining the basement membrane is composed of small, uniform, cubical, transparent, nucleated cells, which are called the *lining cells.* Next to these are cells which appear larger, rounded, and less transparent, and with nuclei showing evidences of proliferation. In the succeeding strata the epithelium exhibits granular cells with very indistinct nuclei. Throughout these various strata the *spermatozoa* are embedded in different stages of development. At first they appear as groups of narrow clavate cells placed with the thick end upward, then as long filaments extending from the several strata of the epithelium into the lumen of one of the tubules, and finally when completely formed the heads are attached to the surface of the epithelium and the tails extend along the canals. The epithelium lining the vasa recta and the vasa efferentia consists of a single layer of the columnar variety, which in the latter is provided with long cilia except toward the globus minor of the epididymis. As the coats of the duct gradually become thicker, circular unstriped muscle-fibres are developed upon them externally to the basement membrane.

The *spermatic artery* arises from the abdominal aorta below the renal artery (Plate 62, No. 15), descends along the psoas muscle, crosses the ureter and the external iliac vessels, and, meeting the vas deferens at the deep abdominal opening, descends in front of it in the substance of the spermatic cord (page 88) to the testicle. Here it sends a branch to the epididymis,—the *epididymal artery*,—and then breaks up into a number of *glandular arteries*, which pierce the corpus Highmorianum of the tunica albuginea at the back of the testicle, whence they are distributed partly along the various septa and partly over the inner surface of the fibrous coat. The minute vessels are supported by fibro-connective tissue, and establish anastomotic plexuses surrounding the seminiferous tubes throughout the lobules, thus forming what is called the *tunica vasculosa* of the testicle. There is, however, no distinct tunic of this kind separable from the general interstitial tissue.

The *spermatic veins* leave the testicle also at the corpus Highmorianum, and, receiving the veins from the epididymis, unite to form the *pampiniform plexus*, which constitutes the chief bulk of each spermatic cord within the scrotum, and, passing upward in front of the vas deferens, terminate in a single efferent trunk, which upon the right side empties into the inferior vena cava and upon the left side into the left renal vein (Plate 62, Nos. 15 and 24). The veins of the pampiniform plexus are very liable to become varicose, and then are so enlarged that they feel—to use an old comparison—like a bundle of earth-worms, and constitute *varicocele*. Among the many causes which conduce to this affection, the most probable are their dependent position, the inefficiency of the valves in the large veins, and the peculiarly long course of the main efferent vein before its termination. That the left veins are more commonly affected than the right is due to the left efferent vein joining the corresponding renal vein at a right angle, where the terminal orifice is usually guarded by a well-developed valve, and also to its exposure to pressure from the contents of the sigmoid flexure of the colon, beneath which it ascends.

The testicle derives its *nerves* from the spermatic plexus, which is contributed to by filaments from the renal, aortic, and hypogastric

plexuses. They accompany the arteries of the cord, and through their connections give rise to the sympathetic disturbances of the stomach and intestines which follow contusions of the gland. The *lymphatic vessels* from the testicle convey their lymph to the lumbar lymphatic glands. In considering the vascular and the nervous supply to the testicle, the original position of the organ within the abdominal region should not be forgotten, as it explains much that would otherwise be enigmatical.

The *vas deferens* (Plate 65, Fig. 3, No. 2) has already been described as originating at the globus minor of the epididymis and afterward passing upward with the cord to the groin (page 88). Upon reaching the deep abdominal opening it leaves the other constituents of the cord and turns round the outer side of the deep epigastric artery. Crossing the external iliac vessels, it then descends into the pelvic cavity, passing over the side of the bladder if distended (Plate 74, Fig. 1, No. 8), between it and the corresponding ureter, and, after becoming somewhat sacculated at the base of the bladder (Plate 78, Fig. 2, No. 19), joins the duct of the contiguous seminal vesicle at its inner side and forms the *ductus communis ejaculatorius.* The vas deferens conveys the spermatozoa and the fluid secretion of the testicle to the prostatic portion of the urethra. When removed from the body and uncoiled, the vas deferens measures sixty centimetres, or two feet. It is remarkable for the thickness of its wall and the comparative minuteness of its passage until it reaches the *ampulla,* above its termination, where the wall is thinner. The structure consists of unstriped longitudinal and circular muscular fibres, with an outer covering of fibro-connective tissue and an internal mucous lining. The latter presents some similarity in the ampulla to the mucous lining of the gall-bladder, being reticularly folded and beset with a few tubular glands. The tense, firm character of the vas deferens renders it easily recognizable from the other constituents of the spermatic cord. It is furnished with a special artery,—the *artery of the vas deferens* (Plate 65, Fig. 3, No. 4),—usually derived from the superior vesical, which in relation to the epididymis anastomoses with the spermatic artery.

The seminal vesicles (*vesiculæ seminales*) serve as reservoirs for the

semen. They are situated between the base of the bladder and the rectum, and diverge from one another somewhat like the branches of the letter **V** (Plate 78, Fig. 2, No. 7). They present great variation in size and conformation, and have an irregular, sacculated appearance. They are held firmly in position by an expansion of the recto-vesical fascia containing some muscle-fibre, their outer borders being in relation above to the termination of the ureters and below to the lateral lobes of the prostate, while the inner borders are attached to the ampullæ of the vasa deferentia. The terminations of the seminal vesicles run side by side with those of the vasa deferentia, and then unite with them to open by a common ejaculatory duct into the prostatic sinus of the urethra (Plate 75, Fig. 2, No. 17). Their coats are similar to those of the seminal ducts, but thinner, and their mucous lining presents the same reticular condition as in the ampulla. Their *arteries* are branches of the inferior vesical and middle hæmorrhoidal. The nerves come from the hypogastric plexus, and the lymphatics, which are numerous, end in the pelvic glands.

The *semen* is a glairy, whitish fluid, consisting of the commingled secretions of the testicles, the ampullæ, and the seminal vesicles, and containing the *spermatozoa*, the essential element of fecundation. The spermatozoa are found in the straight portions of the seminiferous tubules, the rete testis, the convoluted tube of the epididymis, and the vas deferens. They are accumulated in the ampullæ and the seminal vesicles. Each *spermatozoon* appears under the microscope as a very minute tadpole-like body with a flattened ovoid head and a long filamentary tail. The head is depressed in the centre, so that it has the appearance of a nucleus. They measure about one-five-hundredth of an inch in length, and possess a wonderful degree of persistent mobility, which consists in an undulation of the tail, by which the head is made to progress. Besides the spermatozoa there are a number of fine granular corpuscles, the *seminal granules*, and the *liquor seminis*, which is of an albuminous composition.

The *rectum in the male* is more curved than in the female, and, on the whole, its dimensions are not so large. Its anatomy is fully described on page 45. Owing to the intimate relation between the anterior wall

of the lower portion of the rectum and the triangular space at the base of the bladder, it is important in this connection to consider how much can be ascertained by a digital examination in the male.

When the bladder is distended, the finger introduced through the anus can make out the contour of the prostate gland, above and posterior to which is the contiguous under surface of the trigonum vesicæ, with the seminal ducts and vesicles upon each side. The prostate is four centimetres, or about an inch and a half, from the margin of the anus, and therefore thoroughly to explore the trigonum the bladder should be previously fully distended. It is where the rectal wall is in relation to the trigonum that the operation of tapping the bladder per rectum is resorted to for retention of urine. If a catheter is passed along the urethra it can be readily felt through the rectum while in the membranous portion, and thus directed, if necessary, in its course into the bladder. There is a considerable amount of intervening tissue between the membranous portion of the urethra and the end of the rectum in the male, and between the latter and the vagina in the female, which is called the *perineal body.*

Upon removal of the viscera from the pelvic cavity the branches of the internal iliac artery and vein and the sacral plexus of nerves are brought into view (Plate 76, Fig. 1, Nos. 13 and 15).

The internal iliac artery in the adult is four centimetres, or about an inch and a half, in length, usually arising from the common iliac artery (page 73) at the upper border of the sacro-iliac joint and, descending into the pelvis to a short distance above the greater sciatic notch, divides into anterior and posterior branches. Its diameter in the male is eight millimetres, or about one-third of an inch; in the female it is generally a little larger, and it always increases during pregnancy. The ureter passes across its origin, and between it and the pelvic wall are the external and internal iliac veins, the lumbo-sacral and obturator nerves, and the pyriformis muscle. In the fœtus the internal iliac artery is larger than the external, and, as the bladder at that period of life is more within the false pelvis than within the true, the artery does not descend, but continues as the hypogastric artery to the umbilicus

(Plate 26, Vol. I., Fig. 2). From the *anterior branch of the internal iliac* arise the following arteries, either separately or by a common trunk. The *superior vesical artery* is the first, and is the unobliterated portion of the original hypogastric artery. From it arise the *middle vesical artery*, the little *deferential artery*, which accompanies the vas deferens and anastomoses with the spermatic artery upon the testicle (page 149), and a few twigs to the ureter. The *obturator artery* usually arises immediately below the superior vesical and passes directly forward below the obturator nerve and between the peritoneum and the pelvic fascia (page 128) to the obturator canal, at the inner border of which it sends a nutrient branch to the adjacent bone, and an *epigastric* branch which communicates with the deep epigastric artery from the external iliac. It is this branch which sometimes is enlarged and replaces the main trunk from the internal iliac artery, and it is of importance on account of the relation which it bears to the femoral opening (page 99). It also plays a chief part in the collateral circulation after ligation of the external iliac artery, becoming greatly enlarged and conveying blood from its communications directly to the deep epigastric. The obturator also gives off a pubic branch which establishes with its fellow a rete behind the symphysis pubis. The *inferior vesical artery* and the *middle rectal* or *hæmorrhoidal artery* usually arise in common below the obturator. The former supplies the structures at the base and neck of the bladder, establishing a free anastomosis, especially about the prostate gland, with the branches of the corresponding artery from the opposite side. The latter supplies the contiguous wall of the rectum and communicates with the other rectal arteries. In the female, the *uterine artery* arises close to the middle rectal artery and passes between the layers of the broad ligament, forming upon each side a looped arch with the ovarian artery from the abdominal aorta. The anterior division of the internal iliac terminates in the pudic and sciatic arteries, which descend on the pyriformis muscle and the sacral plexus of nerves to the lower part of the greater sciatic notch.

The *pudic artery* is smaller than the sciatic, behind which it generally passes out through the greater sciatic notch and then turns in through

PLATE 72.

Figure 1.

View of a female pelvis from behind. The sacrum is removed to show the relations of the uterus and its appendages.

1. The left epigastric artery and veins.
2. The bladder partially distended and drawn over the pubes.
3. The left external iliac vein.
4. The left external iliac artery.
5. The left round ligament of the uterus.
6. The left anterior crural nerve.
7. The fundus of the uterus.
8. The left Fallopian tube and ovary, within the layers of the broad ligament.
9. The rectum.
10. Section through the sacrum.
11. The right epigastric artery and veins.
12. The right external iliac vein.
13. The right external iliac artery.
14. The right round ligament.
15. The right anterior crural nerve.
16. The right ovary and Fallopian tube.
17. Section through the sacrum.

Figure 2.

View of a female pelvis from in front, to show the relations of the uterus and its appendages to the external iliac vessels.

1. The inferior vena cava.
2. The right renal artery.
3. The right kidney.
4. The right ureter.
5. The right external iliac artery.
6. The recto-uterine fold of the peritoneum.
7. The right external iliac vein.
8. The fundus of the uterus.
9. The right ovary and Fallopian tube.
10. The bladder partially distended.
11. The right round ligament.
12. The abdominal aorta.
13. The left renal artery.
14. The left ureter.
15. The superior hæmorrhoidal artery.
16. The sigmoid flexure of the colon held aside.
17. The left external iliac artery.
18. The left external iliac vein.
19. The left ovary and Fallopian tube.
20. The left round ligament.

Figure 3.

Antero-posterior vertical section of a female pelvis, showing the normal relations of the viscera *in situ* and the reflections of the peritoneum. (This and the four figures on Plate 73 were taken in succession from the same subject, aged twenty-seven years.)

1. The common iliac vein.
2. The common iliac artery.
3. The sigmoid flexure of the colon.
4. The cut end of the external iliac vein.
5. The cut end of the external iliac artery.
6. The promontory of the sacrum.
7. The fundus of the uterus covered with the peritoneum.
8. The anterior and posterior branches of the internal iliac artery.
9. The recto-uterine (Douglas's) fold of the peritoneum.
10. Portion of the broad ligament containing the right ovary and tube.
11. The middle rectal or hæmorrhoidal vessels.
12. The lower portion of the rectum.
13. The coccyx.
14. The anus.
15. The perineal body.
16. The labia majora.
17. The epigastric fold of the peritoneum.
18. The peritoneum over the top of the bladder.
19. The vesico-uterine fold of the peritoneum.
20. The bladder distended.
21. The broad ligament.
22. The pubes.
23. The vesico-vaginal plexus of veins.
24. The clitoris.

Fig 1

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Fig 3

Fig 2

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Dissected Photographed and Colored from Nature by George Mc Clellan. M D

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the lesser sciatic notch, and in company with the pudic vein and nerve is provided with a special expansion of the obturator fascia in relation to the obturator internus muscle. Its terminal branches supply the perineum, scrotum, and penis, and are particularly described with the region of the perineum (page 167). In some bodies the pudic artery, instead of passing out of the pelvis, passes straight by the side of the prostate gland, so that it may give rise to dangerous bleeding if wounded in perineal lithotomy. Before it leaves the pelvis it furnishes muscular branches to the neighboring pyriformis, coccygeus, and internal obturator muscles. This artery is comparatively smaller in the female. The *sciatic artery* passes out through the greater sciatic notch to the region of the buttock (page 227), where it accompanies the great sciatic nerve between the tuberosity of the ischium and the great trochanter of the femur. Within the pelvis it also furnishes muscular branches to the pyriformis, coccygeus, and levator ani muscles, and sends twigs to the seminal vesicles and the rectum.

The arteries from the posterior division of the internal iliac are the following. The *ilio-lumbar* resembles the aortic lumbar branches. It passes upward beneath the psoas muscle and the external iliac vessels to the superficial surface of the iliacus muscle (Plate 63, No. 39), where it divides into an iliac and a lumbar branch. The *lumbar* branch is distributed to the psoas muscle, anastomoses with the lower two lumbar arteries, and sends a spinal branch to the cauda equina through the lumbo-sacral foramen. The *iliac* branch furnishes a nutrient vessel to the ilium, and establishes anastomoses with the circumflex iliac and last lumbar arteries.

The *lateral sacral arteries* are generally two on each side, descending in front of the sacral foramina. The upper artery passes through the first sacral foramen, while the lower sends branches through the second, third, and fourth foramina. Each branch distributes small twigs to the pyriformis muscle and sacral plexus of nerves and the neighboring wall of the rectum. They anastomose with the sacro-media artery and the corresponding lateral sacral arteries. The *gluteal artery* is quite large, and passes at once from its origin through the greater sciatic notch

above the pyriformis muscle, and then divides into superficial and deep sets of branches (Plate 85, Nos. 23 and 46), which are described with the gluteal region (page 223).

The veins of the pelvis correspond with the arteries, draining the territories which they supply, receiving tributaries from the great plexuses about the prostate, the neck of the bladder, and the rectum, already described (page 129), and empty into the internal iliac veins.

The sacral plexus of nerves (Plate 63, No. 22, and Plate 76, Fig. 1, No. 22) consists of the lumbo-sacral nerve, the anterior divisions of the three upper sacral nerves, and part of the fourth. These large nerve-cords rest upon the pelvic surface of the pyriformis muscle behind the pelvic fascia, which separates them from the internal iliac vessels, as already described (page 126). They diminish in size as they issue from the anterior sacral foramina, and converge to the greater sacro-sciatic foramen, whence they pass for the most part as a consolidated broad flat cord, the *great sciatic nerve* (page 227), usually beneath the pyriformis muscle, while the smaller and more plexiform portion is continued as the *pudic nerve* (page 167). From the plexus are derived *muscular branches*, which supply the pyriformis, obturator internus, gemelli, quadratus femoris, and glutei muscles; and *cutaneous branches*, the small sciatic and perforating cutaneous nerves. Of the muscular branches the most conspicuous are the superior and inferior gluteal nerves. The *superior gluteal nerve* consists of filaments from the lumbo-sacral cord and the first sacral nerve, and, passing beneath the pyriformis muscle, accompanies the gluteal vessels, dividing into upper and lower branches to supply the gluteus medius and gluteus minimus muscles. The *inferior* or *recurrent gluteal nerve* is derived from the lumbo-sacral cord and the first and second sacral nerves, and supplies the gluteus maximus muscle. The *small sciatic nerve* is derived chiefly from the second and third sacral nerves. It supplies the skin over the buttock (page 221), the perineum (page 163), and the scrotum, as well as the back of the thigh and leg (Plate 89). The *perforating cutaneous nerve* is a small branch from the fourth sacral nerve which supplies the skin over the gluteal fold of the buttock.

The pelvic sympathetic nerves are similar in their arrangement to those of the abdomen, with which they are directly associated (page 77). They consist of a chain of four or five ganglia extending along each side of the sacrum internally to the anterior sacral foramina, terminating and uniting in front of the coccyx in the *ganglion impar.* The ganglia are brought into relation with the sacral nerves by external branches, while internal branches pass to the *pelvic plexuses* upon each side of the rectum. From the latter numerous delicate filaments accompany the arteries supplying the viscera and form secondary plexuses known respectively as the *inferior rectal plexus,* the *vesical plexus,* the *prostatic plexus,* the *vaginal plexus,* and the *uterine plexus.*

The pelvic lymphatic vessels are very numerous and large, and for the most part accompany the tributaries to the internal iliac vein. They derive their lymph from various sources, as follows. The *obturator lymphatics* pass to a little gland below the obturator vessels; the *pudic lymphatics* (from the perineum), the *gluteal lymphatics,* and the *sciatic lymphatics* are associated with glands situated on the side of the pelvis, between the external and internal iliac vessels. Of the latter there is usually a single gland on the gluteal lymphatics which is prominent below the pyriformis muscle. The efferent vessels from these glands join with the vessels from the bladder and prostate in the male, or from the bladder, vagina, and uterus in the female, and unite in the hypogastric lymphatic glands, in relation to the internal iliac veins, with the efferent vessels from the external iliac lymphatic glands. The latter are generally three in number, and receive the lymph from the femoral and inguinal lymphatics, as well as from the epigastric and circumflex iliac lymphatics from the wall of the abdomen. Besides these there is a fine mesh of lymphatic vessels, constituting the *sacral lymphatic plexus,* upon the hollow of the sacrum, which receive the lymph from the back wall of the rectum and are associated with little glands near the anterior foramina. The efferent vessels from this plexus unite partly with the internal iliac lymphatics and partly with the common iliac lymphatics, and thence they all pass to the lumbar lymphatic glands on the back wall of the abdomen.

THE REGION OF THE PERINEUM.

The perineum is the lozenge-shaped space included by the outlet of the pelvis. Its framework consists of the pubic arch and the sub-pubic ligament in front, the rami of the pubes and ischia and the tuberosities of the ischia at the sides, and the great sacro-sciatic ligaments, the margins of the two great gluteal muscles, and the tip of the coccyx, behind. These can usually be felt and determined through the skin, and should always be carefully examined before approaching the study of the deeper parts, as they are important landmarks.

The *skin* in this region is dark-colored, comparatively thin, and in front of the anus is marked by a *raphê* which continues along the middle line of the scrotum and the under surface of the penis in the male, while in the female it extends only from the anus to the posterior commissure of the vulva. The average measurement of the perineal space is eighty-seven millimetres, or about three and a half inches, transversely between the ischial tuberosities, and one hundred millimetres, or about four inches, from the tip of the coccyx to the pubic arch; but it should be remembered that the dimensions of the perineum vary in different subjects, and that the antero-posterior measurement is always greater in the natural state than in the outlet of the dried skeleton, owing to the curving of the surface-tissues.

The perineal space may be considered as consisting of two sub-regions, separated from each other by an imaginary curved line drawn from one ischial tuberosity to the other in front of the anus, which is in the middle line between the tuberosities, two and a half centimetres, or about an inch, from the coccyx. The anterior portion of the space is the *genito-urinary region,* and the posterior is the *anal* or *ischio-rectal region.* The perineum is separated from the pelvic cavity by the levatores ani muscles and the recto-vesical fascia: the modifications of the arrangement of the latter peculiar to this region in the two sexes have already been referred to (page 127).

The male perineum (Plate 76, Fig. 3, Plates 77 and 78).—In the

male, upon the surface in the middle line between the anus and the scrotum, is the *central point of the perineum*, which overlies the central tendinous intersection of the subjacent muscles (page 163). In front of this point can be noticed a gentle elevation corresponding to the bulb of the spongy portion of the urethra. The raphé is usually selected as a safe line for incision in this region because of its general freedom from blood-vessels, but it is easily displaced and cannot always be relied upon as indicating the middle line. Over the ischio-rectal portion of the perineal space the skin is corrugated about the anus, and is very delicate where it blends with the mucous lining of the bowel, its epidermis being prolonged inward nine millimetres, or about one-third of an inch. It is of a brownish hue, and is provided with hairs which are directed forward and inward toward the scrotum and converge behind the anus toward the coccyx.

The *anus*, or rectal orifice, is an irregular puckered opening two centimetres, or about three-fourths of an inch, in length, during life, when not distended. The wrinkling of its margin is caused by the contraction of a thin layer of involuntary muscle-fibres in the subcutaneous tissue, called the *corrugator cutis ani muscle.* Close to the verge of the anus there are clusters of papillæ, and many minute glands which secrete an oily substance. On the border-line between the skin and the mucous membrane the anal veins often present varicosities, which, when large, constitute *external piles.* This border-line also presents a fine white streak, which indicates the interval between the external and internal sphincter ani muscles (Hilton). The *anal* branch of the pudic nerve supplies the skin of the verge of the anus; and the great pain often experienced in a *fissure of the anus* is due to the exposure of one of the filaments of this nerve in the torn tissue.

When the skin is carefully removed from over the *entire* perineal space (Plate 76, Fig. 3), the *subcutaneous tissue* will be found to present different characters which adapt it to the requirements of the several localities. Over the root of the penis and the scrotum the superficial layer is destitute of fat and consists of elastic connective tissue, but toward the deeper parts it contains fat in its meshes, which increases in

quantity posteriorly and on either side of the rectum completely fills the two pyramidal hollows known as the **ischio-rectal fossæ.** These fossæ become more or less conspicuous in emaciation. They are from five to seven and a half centimetres, or from two to three inches, in depth, and the fatty cushions which they contain afford an elastic support to the lower end of the bowel during the passage of the fæces. They are frequently the seat of furuncles, abscesses, or fistulæ, owing to the fatty tissue being poorly nourished and prone to inflammation from exposure. An *ischio-rectal abscess* is limited by the walls of the fossa in which it occurs,—the obturator internus muscle covered by its expansion from the pelvic fascia (page 127) being on the outer side, the levator ani muscle covered by the anal fascia on the inner side, in front the transversus perinei muscle and the posterior margin of the triangular ligament, and behind the gluteus maximus and coccygeus muscles with the greater sacro-sciatic ligament. An abscess in this locality, therefore, tending to discharge in the direction of least resistance, will break either through the surface-skin or through the wall of the rectum. The lower part of the rectum situated between the two fossæ is supported by the levatores ani and external sphincter muscles and the recto-vesical fascia. The depth of the perineum varies considerably in different bodies, depending chiefly upon the amount of the fat, being generally about three inches in relation to the lateral wall of the rectum. It should be noted in this connection that, owing to the attachment of the levator ani muscle (page 167) and of the anal fascia to the bowel, the opening into the latter in an ordinary case of fistula is nearly always within thirteen millimetres, or half an inch, of the anus.

The fat in the ischio-rectal region is continuous with that of the superficial fascia of the buttocks and thighs. Over the ischial tuberosities there are tough fibrous septa, extending from the skin to the bone and interspersed among the coarse fat, which thus forms a natural padding. This is occasionally reinforced by the development of irregular bursæ.

The *external sphincter ani muscle* (Plate 76, Fig. 3, No. 5) is very closely associated with the skin, from which it is difficult to separate it

except in the most recent state. It is elliptical, consisting of two layers of curved fibres which arise from the *ano-coccygeal ligament* and the tip of the coccyx, and, surrounding the anus, are attached mainly by a pointed slip at the central tendon of the perineum. There are numerous fibres from the *superficial layer* which intermingle with the several adjacent muscles and decussate with one another in front of and behind the anus. The *deep layer* is in relation with the *internal sphincter ani muscle,* which is the ring of involuntary circular and muscular fibres surrounding the lower portion of the rectum (page 46), six millimetres, or about a quarter of an inch, from the margin of the anus.

The external sphincter is a *voluntary* muscle supplied by the *fourth sacral nerve* (Plate 77, Fig. 1, No. 34), and by its tonic action it keeps the anus closed. In the operation of *fistula in ano* the external sphincter is divided, in order to keep the parts at rest during the healing process, and the incision should be made parallel to the course of the *inferior rectal vessels.* These vessels arise from the pudic, and cross obliquely with the anal nerves through the ischio-rectal fossa to the lower wall of the rectum and the skin about the anus. Occasionally they are of large size, and if wounded may give rise to troublesome bleeding. When the fat is removed from the fossa upon either side, the *pudic vessels* and *nerve* will be exposed embedded in the fascia over the obturator internus muscle three centimetres, or about an inch and a quarter, above the lower border of the ischial tuberosity (Plate 76, Fig. 1, No. 30). The pudic vessels and nerve approach nearer the surface as they pass forward in relation to the pubic arch. The pudic artery arises from the anterior branch of the internal iliac artery, and is particularly described with the dissection of the pelvis (page 153).

The superficial fascia over the urethral region is very thin and free from fat toward the scrotum, as already stated (page 141). It is continuous laterally over the rami of the ischia with the superficial fascia of the thighs, but in the middle line is adherent both to the skin along the raphé and to the deep fascia, so that it offers a barrier to the ready passage of infiltration from side to side. The *superficial branch of the perineal nerve* passes between the superficial and deep fasciæ to

PLATE 73.

Figure 1.

Vertical median section of female pelvis, showing the relations of the bladder, vagina, and rectum (all partially distended).

1. The common iliac artery.
2. The termination of the colon.
3. The cut end of the external iliac vein.
4. The cut end of the external iliac artery.
5. The commencement of the rectum.
6. The promontory of the sacrum.
7. The fundus of the uterus covered with the peritoneum.
8. The cut end of the internal iliac artery.
9. The recto-uterine (Douglas's) fold of the peritoneum.
10. The right ovary, seen on the under surface of the broad ligament, which is drawn outward and reflected.
11. The muscular coat of the rectum.
12. The middle rectal, or hæmorrhoidal, artery.
13. The broad ligament.
14. The lower portion of the rectum.
15. The coccyx.
16. The anus.
17. The epigastric fold of the peritoneum.
18. The position of the left Fallopian tube.
19. The position of the left ovary.
20. The peritoneum over the bladder.
21. The bladder.
22. Section of the pubes at the symphysis.
23. The neck of the bladder.
24. The urethra.
25. The clitoris.
26. The labium majus.
27. The perineal body.

Figure 2.

Vertical section of female pelvis. The rectum and vagina opened, the bladder and urethra distended. The position of the os uteri is shown in its proper relations.

1. The common iliac artery.
2. The termination of the colon.
3. The cut end of the external iliac vein.
4. The cut end of the external iliac artery.
5. The promontory of the sacrum.
6. The cut end of the internal iliac artery.
7. The neck of the uterus covered with the peritoneum.
8. The recto-uterine (Douglas's) fold of the peritoneum.
9. The middle rectal, or hæmorrhoidal, vessels.
10. The vagina (opened).
11. The rectum (opened).
12. The coccyx.
13. The anus.
14. The epigastric peritoneal fold.
15. The left Fallopian tube and fimbriated extremity.
16. The left ovary.
17. The bladder (distended).
18. The os uteri (externum).
19. Section of the pubes at the symphysis.
20. The urethra (distended).
21. The sub-pubic plexus of veins.
22. The clitoris.

Figure 3.

Vertical section of female pelvis (same as Figure 2), with section of the uterus, showing its cavity.

1. The common iliac vein.
2. The common iliac artery.
3. The sigmoid termination of the colon.
4. The cut end of the external iliac vein.
5. The cut end of the external iliac artery.
6. The promontory of the sacrum.
7. The cavity of the uterus.
8. The recto-uterine (Douglas's) fold of the peritoneum.
9. The muscular coat of the rectum.
10. The middle rectal, or hæmorrhoidal, vessels.
11. The rectum (opened).
12. The vagina (opened).
13. The lower valve-like fold in the rectum.
14. The coccyx.
15. The anus.
16. The perineal body.
17. The vaginal opening.
18. The epigastric fold of the peritoneum.
19. The peritoneum over the bladder.
20. The left ovary.
21. The bladder.
22. Section of the pubes at the symphysis.
23. The urethra.
24. The sub-pubic venous plexus.
25. The clitoris.
26. The labium majus.
27. Fat and muscular tissue between the vagina and the urethra.

Figure 4.

Vertical section of female pelvis (same as Figure 3), with bladder and urethra opened.

1. The common iliac artery.
2. The common iliac vein.
3. The sigmoid termination of the colon.
4. The cut end of the external iliac artery.
5. The promontory of the sacrum.
6. The cavity of the uterus.
7. The recto-uterine (Douglas's) fold of the peritoneum.
8. The muscular coat of the rectum.
9. The middle rectal vessels.
10. The rectum (opened).
11. The coccyx.
12. The anus.
13. The perineal body.
14. The vaginal opening.
15. The deep epigastric artery.
16. The position of the obliterated hypogastric artery.
17. The bladder (opened), showing its mucous lining.
18. Section of the pubes at the symphysis.
19. The mucous lining of the urethra.
20. The vagina (opened).
21. The clitoris.
22. The labium majus.

Fig. 1

Fig. 2

Dissected, Photographed and Drawn from Nature by George McClellan M.D.

Armstrong & Co. Lith. Boston

supply the skin of the perineum and the scrotum. This nerve communicates in front with the *inferior pudendal nerve,* which is a branch of the lesser sciatic nerve. It appears above the tuberosity of the ischium, passing over the fascia covering the corresponding ramus of the ischium (Plate 77, Fig. 1, No. 22).

The deep fascia over the urethral region (or *Colles's fascia*) (Plate 76, Fig. 3, No. 2) is a thin strong membrane attached on each side to the rami of the ischia and pubes. Anteriorly it is continuous with the deep fascia of the penis, and in the middle line it is connected with both the overlying superficial fascia and with the median septum of the underlying accelerator urinæ muscle, while posteriorly it is reflected around the anal border of the two transversus perinei muscles, and, turning upward and forward beneath these muscles, becomes the *anterior layer of the triangular ligament* (Plate 77, Fig. 1, No. 9). The reflected border of the deep fascia is strengthened at the *central point of the perineum* by the blending of the attachments of the external sphincter ani, the two transverse perineal, and the accelerator urinæ muscles. Inflation by means of a blow-pipe will demonstrate the distinct separation of the urethral and ischio-rectal regions by the reflection of the deep fascia around the transversus perinei muscles, and this, together with the lateral connections to the rami of the ischia and pubes, explains the course of extravasated urine after rupture of the spongy portion of the urethra, when it passes into the cellular tissue of the scrotum, penis, and groins, but not into the ischio-rectal fossæ or upon the thighs. It should be remembered, as already stated (page 6), that the deep fascia of the urethral region, the dartos tissue of the scrotum, and the deep layer of the superficial fascia of the abdominal wall are in reality merely different parts of the same structure.

When the deep fascia is reflected as shown in Plate 77, Fig. 1, the muscles which cover the bulb of the urethra and the crura of the penis are exposed, forming upon each side an *intermuscular triangle* in which appear the superficial perineal vessels and nerves. Upon each side the *erector penis* or *ischio-cavernosus muscle* arises from the lower and inner border of the tuber cavernosum on the ischio-pubic ramus and the

front of the tuberosity of the ischium, and passes forward to be inserted into the capsule of the corresponding corpus cavernosum penis. These muscles are supplied by the deep perineal nerves, and they serve to depress and compress the crura of the penis. The *accelerator urinæ* or *bulbo-cavernosus muscle* consists of two symmetrically arranged portions united by a median raphé presenting a bipenniform appearance (Plate 77, Fig. 1, No. 6). It is attached posteriorly to the central tendon of the perineum, blending with the outer fibres of the external sphincter, and embraces the bulbous portion of the corpus spongiosum of the urethra, the fibres diverging and leaving in front a V-shaped space. The insertion of this muscle is as follows. The posterior fibres are attached to the triangular ligament on each side of the bulb, the middle fibres surround the bulb and adjacent part of the corpus spongiosum and blend with one another in a tendinous lamella, and the anterior fibres are inserted into the under and outer side of the corpora cavernosa, covering by their expansion the dorsal vessels of the penis. Very often the anterior portion of the fibres appears to be separated and inserted into the fascia over the dorsum of the penis below the pubic arch, and thus constitutes the *compressor venæ dorsalis penis muscle.* The accelerator urinæ is supplied by the deep perineal nerve, and the action of the entire muscle is that of a powerful compressor of the bulb in expelling the last drops of urine after micturition. It also serves to assist the erectores penis muscles in the erection of the organ. The *transversus perinei muscles* consist of muscular fascicles of variable development in different bodies, not uncommonly being wholly absent. They arise from the inner sides of the tubera ischii, and pass forward to join with one another and with the other muscles in the central tendon. Occasionally there is a small accessory muscular slip, called the *deep transversus perinei* or *ischio-bulbosus muscle,* which has a distinct origin beneath the superficial muscle and passes behind the bulb to the central tendon.

The above muscles are all furnished with branches of the *superficial perineal artery* (Plate 76, Fig. 1, No. 24), which leaves the pudic artery at the inner side of the ischial tuberosity, and, after piercing the deep fascia as it is reflected around the transverse perineal muscle,

passes along the border of the erector penis muscle. In relation to the transverse muscle, a branch called the *transverse perineal artery* passes usually superficially upon that muscle to anastomose with its fellow from the opposite side. Both the transverse muscle and the transverse artery are divided in the incision for lateral lithotomy, and the presence of this artery should not be overlooked, as it is sometimes enlarged, taking the place of the deeper bulbar artery (page 167).

The *perineal nerves, superficial* and *deep*, are derived from the *pudic nerve* (page 161), and, following the course of the corresponding arteries, supply the skin of the perineum and scrotum and each of the muscles as above described. When the muscles are removed from the urethral region, the corpora cavernosa, with their whitish fibrous coats, are seen upon each side (Plate 77, Fig. 2), and the bulb of the corpus spongiosum in the middle, with the perineal surface of the triangular ligament appearing between them.

The *triangular ligament of the perineal region,* although undoubtedly important, has been so emphasized and exaggerated by laborious descriptions that the student who attempts to verify these upon the dissecting-table generally becomes bewildered and is forced to accept a great deal on faith. Diagrams are at best but the expression of ideas, and their very distinctness is misleading in producing the impression that all the structures pertaining to this especial locality are bounded by fixed lines. Within the last few years, preparatory to this part of his work, the author has carefully made dissections of the perineum upon some twenty different bodies, all in as recent a state as could be obtained, and the facts which he has thus been able to demonstrate to his own satisfaction are the basis of this description of the anatomy of this region.

It is hoped that from what has already been stated it will be understood that the deep fascia over the urethral portion of the perineum is continuous behind the transverse perineal muscles with the triangular ligament. This membrane consists of a sheet of white fibrous tissue extending transversely between the rami of the ischia and pubes, and practically separating the anterior portion of the pelvic cavity from the

urethral region. It blends anteriorly with the sub-pubic ligament, and is in close contact with the subjacent portion of the obturator fascia, which forms the *sub-pubic fascia* and is usually described as the posterior layer of the triangular ligament (Plate 75, Fig. 1, No. 8). This posterior layer should be regarded as merely an expansion of the general pelvic fascia (page 127), and it certainly is less developed than the strong extra-pelvic fascia constituting the triangular ligament proper. The latter is pierced at the apex beneath the pubic arch by the dorsal vessels and nerves of the penis (page 142), and by the urethra two and a half centimetres, or about an inch, beneath the pubes in the middle line. The sheath of the urethra as it passes through the ligament receives a reinforcement from the membrane, which probably serves as a factor in producing the obstacle which a catheter or sound meets with at this part of the urethral passage, to overcome which it is only necessary in many cases simply to draw the penis forward upon the instrument. It should be noted that in rupture of the urethra anterior to the triangular ligament it is this membrane which prevents the urine from escaping into the pelvis. When, however, urine does escape through a rupture of the membranous portion of the urethra posterior to the ligament, or an abscess occurs in this situation, no time should be lost in making a *section of the perineum* for its evacuation, for there is little hinderance naturally offered by the subjacent tissues to its infiltration into the pelvic cavity. After the triangular ligament has been dissected away (Plate 77, Fig. 2, and Plate 78, Fig. 1) the following parts can be seen. The *membranous portion of the urethra* is indicated by the constriction at the back of the bulb. On either side of it are the *sub-urethral* (or *Cowper's*) *glands* (Plate 78, Fig. 1, No. 6), which have already been described (page 137). The *constrictor urethræ muscle* is a variably-developed layer of muscle-fibres which arises laterally along the rami of the pubes and is inserted into a median tendinous raphé on the wall of the urethra, extending from the bulb to the prostate gland, surrounding, therefore, the membranous portion of the urethra. Fasciculi of this muscle are sometimes separated artificially, and have been differently designated, the transverse fibres being called the *com-*

pressor urethræ muscle (*of Guthrie*), and the oblique fibres the *levatores urethræ muscles* (*of Wilson*). The *deep* transverse perineal muscles sometimes found (page 164) are also specializations of the same layer of muscular tissue. The branches of the pudic artery (page 153) which are seen in this dissection are the artery of the bulb of the urethra, the artery of the corpus cavernosum, and the dorsal artery of the penis. They are all between the proper triangular ligament and its deeper layer, or the sub-pubic fascia.

The *bulbar artery* is the largest, and passes through the substance of the constrictor urethræ muscle to the bulb, sending off branches in its course to Cowper's gland. The artery should be avoided, if possible, in the lateral lithotomy operation, and when it pursues its normal course, four centimetres, or about one and a half inches, above the anus, it is out of the way if the incision is not extended too high in the perineum; but occasionally it is more superficial, or the transverse perineal artery takes its place, as already mentioned (page 165), and it would then necessarily be cut in the operation. In such cases, however, it is not difficult to secure the main trunk with a ligature, since it is more superficial, as was found in a hospital patient operated on by the author several years ago. The *artery of the corpus cavernosum* ascends near the pubic arch, enters the corresponding crus of the penis, and continues by the side of the septum pectiniforme (page 141). The *dorsal artery of the penis* passes forward beneath the crus, pierces the tissues about the suspensory ligament, and continues along the dorsum of the penis (page 141). The veins accompanying the branches of the pudic artery terminate in the *pudic vein*, except the *dorsal vein of the penis*, which communicates with the prostatic plexus of veins (page 128). The *pudic nerve* originates from the lower part of the sacral plexus, and its branches follow the distribution of the pudic artery, and are severally described with the different structures.

The *levator ani muscle* (Plate 77, Fig. 2, No. 9) arises on either side from the posterior surface of the pubic bone below the symphysis, from the curved white line indicating the separation of the obturator and recto-vesical layers of the pelvic fascia (page 126), and from the inner

surface of the spine of the ischium. The fibres of this muscle descend, converging inward toward the middle line, and, uniting with the fibres of the opposite levator muscle, form a sling-like support for the lower part of the rectum. They are inserted anteriorly around the base of the prostate gland, medially into the wall of the rectum between the internal and external sphincter ani muscles, and posteriorly, by far the largest portion, into the ano-coccygeal ligament and the side of the coccyx. There is a segmentation of this muscle which passes from the spine of the ischium to the lower part of the sacrum and the coccyx beneath the lesser sciatic ligament, and is called the *coccygeus muscle.* The anterior fibres of the levator ani, from their relation to the prostate, are sometimes specialized as the *levator prostatæ muscle.* In the female the portion of the levator ani muscle corresponding to the levator prostatæ is attached to the sides of the vagina. Both the levator and coccygeus muscles are supplied by the third and fourth sacral nerves. Upon removal of the above muscles, a view is obtained of the relations of the prostate gland and seminal vesicles at the base of the bladder (Plate 78, Fig. 2), and if the rectum is separated from the recto-vesical fold of the pelvic fascia, and drawn downward and outward, the relative position of the peritoneum can be appreciated (Plate 78, Fig. 2, No. 14). The prostate gland is just behind the triangular ligament, and is surrounded by its capsule beneath the levator ani muscle and the vesico-prostatic plexus of veins (page 128). The base of the bladder, when the body is in the usual position for operating in this region, is six and a quarter centimetres, or about two and a half inches, from the surface.

The female perineum (Plates 73, 79, 80, and 81).—In the female the perineal space presents the genito-urinary region anteriorly and the ischio-rectal region posteriorly, the two being separated by the *perineal body,* consisting of a dense mass of connective tissue covered with a brownish skin. There is very little difference in the ischio-rectal region in the two sexes. The transverse measurement is usually greater, owing to the eversion of the ischial tuberosities (page 111), and the ischio-rectal fossæ are wider and shallower. The anus is somewhat nearer the coccyx, but in other respects closely resembles the anus in the male.

The prominence which extends from the symphysis of the pubes to the perineal body and includes the external orifices of the genital and urinary passages is called the *pudendum*, or *vulva*. It is surmounted at the symphysis by an eminence, the *mons Veneris*, consisting of an accumulation of fatty tissue, over which the skin is provided with thick, curly hair. From this two thick folds of skin, the *labia majora*, descend on each side of the *rima urogenitalis*. They blend beneath the pubes, forming the *anterior commissure*, and, diminishing below, join two and a half centimetres, or about an inch, above the anus, in the *posterior commissure*. Within the latter there is a small transverse fold, the *fourchette*, or *frænulum pudendi*, the space between which and the posterior commissure is called the *fossa navicularis*. The labia majora are homologous to the two halves of the scrotum in the male. The external skin is provided with hairs and sebaceous glands, but the internal surface of each labium resembles mucous membrane, being thinner, smoother, and moist, and marked by the orifices of many sebaceous follicles. Within the labia majora there are two smaller folds, the *labia minora*, or *nymphæ*, which commence about half-way between the commissures, becoming more pronounced as they approach the anterior commissure, where they blend and form a hood-like covering for the clitoris, called the *præputium clitoridis*, and, sending a small band of tissue from each side to the under surface of the glans of that organ, constitute the *frænulum clitoridis*. The structure of the labia minora differs from that of the labia majora in not containing fat, being rather a modified skin enveloping a plexus of small veins. Posteriorly they become lost on the inner sides of the labia majora. The *clitoris* is exposed when the labia minora are separated. It is the homologue of the penis, four centimetres, or about an inch and a half, in length, when stripped of its coverings, but without a corpus spongiosum or a urethra. It is attached by two crura to the pubic arch, and by a suspensory ligament. Its corpora cavernosa are surmounted by a small *glans*, which is furnished with extremely sensitive papillæ. Relatively its dorsal arteries and nerves are large, and they are disposed in a similar manner to those of the penis. Beneath the clitoris there is a smooth

PLATE 74.

Figure 1.

Vertical section of the male pelvis, showing the relative positions of the viscera and the folds of the peritoneum and pelvic fascia. Also the great prostatic plexus of veins.

1. The first portion of the rectum.
2. The right common iliac vein.
3. The right common iliac artery.
4. The right ureter.
5. The cut ends of the right external iliac vein and artery.
6. The recto-vesical fold of the peritoneum, over the second portion of the rectum.
7. The cut ends of the right internal iliac arteries.
8. The right vas deferens, passing backward beneath the peritoneal covering of the bladder.
9. Section through the right lateral mass of the sacrum.
10. The cut ends of the right internal iliac veins.
11. The vesico-prostatic plexus of veins.
12. The muscular coat of the third portion of the rectum.
13. The levator ani muscle.
14. Section through the coccyx.
15. The sphincter ani muscle.
16. The peritoneum, lining the left wall of the abdomen.
17. The deep epigastric vessels, covered by the fold of the peritoneum.
18. The position of the left semilunar fold (of Douglas).
19. The vesico-abdominal fold of the peritoneum.
20. The supra-pubic fat and aponeurosis.
21. The anterior wall of the bladder, uncovered by peritoneum.
22. The body of the distended bladder.
23. Section of the pubes at the symphysis.
24. The dorsal vein of the penis.
25. The cut end of the right spermatic cord.
26. The accelerator urinæ muscle, surrounding the bulb of the spongy portion of the urethra.
27. The anus.

Figure 2.

Vertical section of the male pelvis, showing the region of the prostate gland. (Same as Figure 1.)

1. The first portion of the rectum.
2. The right common iliac artery.
3. The right common iliac vein.
4. The right ureter.
5. Section through the lateral mass of the sacrum.
6. The recto-vesical fold of the peritoneum, over the second portion of the rectum.
7. The cut ends of the right internal iliac arteries.
8. The right vas deferens, passing here onward beneath the peritoneum.
9. The cut ends of the right internal iliac veins.
10. The right seminal vesicle.
11. The third portion of the rectum, showing its muscular layer.
12. The prostate gland.
13. The recto-vesical layer of the pelvic fascia.
14. The coccyx.
15. The levator ani muscle.
16. The sphincter ani muscle.
17. The peritoneum, lining the left wall of the abdomen.
18. The peritoneal fold of the deep epigastric vessels.
19. The position of the urachus.
20. The summit of the bladder, covered by the vesico-abdominal fold of the peritoneum.
21. The body of the bladder.
22. Section of the pubes at the symphysis.
23. The dorsal vein of the penis.
24. The position of the triangular ligament.
25. The position of the membranous portion of the urethra.
26. The accelerator urinæ muscle, over the bulb of the spongy portion of the urethra.
27. The cut end of the right spermatic cord.
28. The perineum.

Fig. 1

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triangular surface, called the *vestibule*, in the back part of which, two and a half centimetres, or about an inch, below the clitoris, is the orifice of the urethra (page 117), the *meatus urinarius*, surrounded by an elevation of the mucous membrane (Plate 79, No. 3). The meatus is rounded and puckered, and not a vertical slit like that of the penis. The *orifice of the vagina* is just below the meatus. When closed, it appears as a vertical slit, becoming elliptical when expanded. It is narrowed in the young female by the presence of a thin fold of mucous membrane, the *hymen*, which is very variable in form and development. Ordinarily it extends across the lower part of the vaginal orifice with a crescentic border directed upward. After its rupture its border appears singularly scalloped, and is called the *carunculæ myrtiformes*.

When the vagina and the lower part of the rectum are packed with oakum and their orifices are closed with stitches, the skin and superficial fascia can be removed, and the various muscles, vessels, and nerves in this region can be dissected, as shown in Plates 79 and 80, provided the parts are in a good state of preservation and well developed. Of the special muscles which occupy the genito-urinary region in the female, those which are deserving of attention as presenting peculiar differences from the muscles in the same situation in the male are the following. Upon each side the *erector clitoridis* or *ischio-cavernosus muscle* resembles the erector muscle of the penis in the male, but is proportionately smaller. It arises from the ischial tuberosity and embraces the corresponding crus of the clitoris. The *sphincter vaginæ* or *bulbo-cavernosus muscle* is analogous to the accelerator urinæ in the male. It consists of fibres which arise from the central tendon of the perineum, and, surrounding the orifice of the vagina, unite anteriorly by being inserted into the corpora cavernosa clitoridis and to the submucous tissue of the vestibule. A slip from each side of this muscle crosses the body of the clitoris, and serves to compress the dorsal vein. At the central tendon the fibres of the sphincter vaginæ blend with those of the external sphincter ani, so that the two muscles together present somewhat the form of the figure 8. The *transversus perinei muscles* are difficult

of satisfactory demonstration, but usually appear divided into fasciculi, which are respectively inserted into the sphincter vaginæ, the levator ani, and the wall of the lower part of the rectum. The above muscles constitute an intermuscular triangle, as in the male, but smaller. When they are removed (Plate 80, Fig. 1), the corpora cavernosa of the clitoris and the vaginal bulbs are exposed. The *corpora cavernosa of the clitoris* are diminutive representatives of the same portions of the penis. The *vaginal bulbs* (Plate 80, Fig. 1, Nos. 6 and 18) are two oblong masses of erectile tissue placed upon either side of the opening of the vagina. They are joined anteriorly over the urethra by a narrow portion (called the *pars intermedia*), which consists of a large venous plexus and is prolonged into the *glans clitoridis*. Beneath the vaginal bulbs and the corpora cavernosa is the sub-pubic fascia, or *triangular ligament* (Plate 80, Fig. 1, No. 9), which is wider than it is in the male, but naturally looser and weaker, owing to its being pierced by the vagina as well as by the urethra, the two orifices of these passages being separated by a very narrow band of the fibrous tissue of the membrane. The attachment of the pelvic fascia to the triangular ligament is closer than it is in the male, and it is even less distinguishable as its posterior layer. Beneath the proper sub-pubic fascia and the indefinite pelvic fascia are structures which are analogous to those found in relation to the membranous portion of the male urethra. Upon each side there is a yellowish, racemose, glandular body (*gland of Bartholin*), resembling the similarly-situated sub-urethral gland of Cowper, but much larger. The ducts from these glands are two centimetres, or about three-fourths of an inch, in length, and open at the middle of the side of the vaginal orifice just within the labium minus. Within these deep fascial layers there are also variously developed muscle-fibres, which occasionally present definite form and attachment, so that they have been specialized as the *constrictor vaginæ muscle*, consisting of fibres arising at the deep border of the central tendon and circling round the vaginal orifice; the *depressor urethræ muscle* (Plate 80, Fig. 2, No. 10), formed by some fibres which, arising from the deep surface of the ischial tuberosity, pass upward and inward over the urethra and blend with corresponding fibres from the

opposite side; and a deep transverse perineal muscle, very similar to that in the male. The branches of the pudic vessels are smaller than the corresponding branches in the male perineum, but in all essential respects the description of the one answers for the other. The pudic artery and its veins can be more easily exposed to view in the female, owing to the greater width of the space and to the eversion of the ischial tuberosities. The branches of the pudic nerve also correspond in the main to the pudic branches in the male. They are especially well shown in Plate 79.

THE REGION OF THE BACK.

This region properly extends from the occiput to the sacrum, and its several portions are naturally included in the separate regions of the neck, thorax, loins, and buttocks. The structures composing the back of the neck and the back of the thorax in relation to the upper extremity and the articulations of the ribs to the spinal column are thoroughly described in Vol. I. A *topographical survey of the entire back* is of practical clinical value, and is given in Plate 82, which is based upon careful examinations of both the living and the dead body, and may be studied to advantage by comparing it with a similar survey of the anterior view shown in Plate 27, Vol. I.

Before explaining the anatomy of the deep structures of the back not previously described, the superficial view of the back, including the landmarks, will be briefly considered.

When the body is held erect with the shoulders squared and the arms hanging naturally at the sides (Plate 82), the **surface-markings of the back** which can be distinguished are as follows. In the median furrow caused by the lateral bulging of the deep longitudinal muscles the spines of the seventh cervical vertebra (*vertebra prominens*) and first dorsal vertebra are usually noticeable, and by counting downward the succeeding spines may be determined. The spines through the entire series, except that of the second cervical vertebra, may be brought into relief and detected by sight as well as by touch by bending the body

forward. They never occupy an exactly straight line, being normally slightly divergent to the right in the thoracic portion of the vertebral column, where they are obscured in the upright position except when the body is emaciated. In the lumbar region the spines can usually be seen on the surface, because of the intimate association of the skin with the lumbar aponeurosis and the subjacent supra-spinous ligaments, which produces a series of vertical dimplings corresponding to the lumbar spines. It should be remembered, as already pointed out (page 249, Vol. I.), that owing to the obliquity of the vertebral spines in the thoracic portion of the column they are not opposite the corresponding vertebral bodies. Their relative positions are given in connection with the exits of the spinal nerves (page 206). The spines of the scapulæ can be felt through the skin, and when the arms are crossed upon the chest they correspond to the level of the fourth dorsal spine and ascend outwardly to the points of the shoulders. The inferior angles of the scapulæ when the arms are in the above position are on the level of the seventh dorsal spine. In the movements of the upper extremity the vertebral borders of the scapulæ hold very different relations to the spinal column, for when the shoulders are thrown back, with the arms at the sides, the inferior angles of the scapulæ in the adult are seven and a half centimetres, or about three inches, apart, whereas when the arms are crossed upon the chest the interval between them measures thirty centimetres, or about twelve inches, so that the latter is the best position for the medical examination of the back of the thorax. The *interscapular space* may even be increased to forty centimetres, or sixteen inches, by raising the arms above the head.

The most reliable *landmarks* for clinical purposes in this region are as follows (Plate 82). The third dorsal spine is about opposite the bifurcation of the trachea; the fourth dorsal spine indicates the position of the base of the heart, while the eighth dorsal spine corresponds to its lower level and to the central tendon of the diaphragm. The tenth dorsal spine corresponds to the lower borders of the lungs, which, when fully expanded, follow the upper borders of the eleventh ribs. The second lumbar spine is opposite the termination of the duodenum, and

also opposite the commencement of the cauda equina within the spinal canal. The fourth lumbar spine is opposite the bifurcation of the aorta.

The *skin of the back* is provided with a very thin epidermis, and is covered with very delicate short hairs which are directed downward toward the middle line. There are comparatively few sebaceous and sudoriferous glands, the former being large over the scapulæ, and the latter especially so over the loins. The sensibility of the skin of the back is low, as compared with that of the skin over the front of the body. The skin is generally closely adherent to the superficial fascia, which is dense and tough and in the well-nourished individual contains much fat, and is attached to the supra-spinous ligaments through the entire length of the spinal column. In the lumbar region the superficial fascia contains less fat in its meshes, and after death often presents a gelatinous appearance, owing to hypostatic infiltration.

After the skin and superficial fascia have been removed, the superficial muscles, together with the cutaneous vessels and nerves, are exposed (Plate 83, Fig. 2), symmetrically arranged on both sides. The upper six nerves are the *internal branches of the posterior dorsal spinal nerves*, and they appear at the sides of the spinous processes, penetrating the sheath of the trapezius muscle. Below these there are nine cutaneous nerves, of which the first six are derived from the *external branches of the posterior dorsal spinal nerves* and appear opposite the angles of the respective ribs, penetrating the lumbar aponeurosis, and the lower three are derived from the posterior lumbar spinal nerves and descend in relation to the posterior portion of the crest of the ilium. There are also several small cutaneous twigs from the posterior sacral nerves which pierce the fascia in the neighborhood of the sacrum. Each of the dorsal spinal nerves is accompanied by a posterior branch of the corresponding intercostal or lumbar artery. The *trapezius muscle* is described on page 208, Vol. I.

The latissimus dorsi muscle arises from the lower six dorsal spines and their supra-spinous ligaments, under cover of the trapezius muscle (Plate 83, Fig. 2, No. 5), from the lumbar fascia, and from the upper two sacral spines and the adjacent portion of the external

lip of the crest of the ilium, and, receiving fleshy strips from the three lower ribs, which interdigitate with the external oblique muscle of the abdomen, passes to be inserted by a flat tendon, four centimetres, or about an inch and a half, in breadth, into the floor of the bicipital groove of the humerus (page 329, Vol. I.). The fibres twist on themselves as they converge toward the axilla, and, curving over the inferior angle of the scapula, are so disposed at their insertion that the fibres from the upper portion become the lowest in the groove, and the fibres from the lower portion the highest. The latissimus dorsi and the teres major form the posterior fold of the axillary region (page 337, Vol. I.), and their tendons are separated by a bursa, although they are commonly united at their contiguous borders, the tendon of the latissimus dorsi being attached in front of and higher than that of the teres major.

The latissimus dorsi is usually held in relation to the inferior angle of the scapula by a dense band of connective tissue, and very often receives a distinct accessory muscular slip from the bone. The object of this attachment, as well as of the manner in which the high origin of the muscle is covered by the trapezius, is that the scapula may be kept applied to the chest-wall in the movements of the upper extremity. Occasionally there appears to be no connection between the muscle and the inferior angle of the scapula, and sometimes the connection may be severed by violence. It should be noted that when the scapula is not firmly held against the ribs the arm cannot be raised beyond a right angle (page 335, Vol. I.). There are also very frequently found accessory slips extending from the latissimus dorsi to the sheath of the axillary vessels and to the long head of the triceps muscle, which are the survivals of expansions occurring in the early embryonic condition. The action of the latissimus dorsi muscle is to draw the arm inward and backward, co-operating with the pectoralis major; but if the arm is the fixed point the muscle assists in raising the trunk, as in climbing. When the arm is raised there is a small *posterior scapular triangle*, which exposes the rhomboid muscle and renders the sixth intercostal space subcutaneous. In the loin just above the crest of the ilium there is also a triangular space, formed by the

margins of the latissimus dorsi and external oblique muscles, which is floored by a portion of the internal oblique muscle. This is known as the *triangle of Petit.* It is always largest in the adult female. The latissimus dorsi is supplied by the long sub-scapular nerve and the sub-scapular artery, which enter the muscle on its axillary surface on a level with the fourth rib (Plate 45, Vol. I., Nos. 14 and 15). The rhomboideus muscle is exposed upon removal of the trapezius muscle, and has been described in Vol. I. Beneath the rhomboideus is the *serratus posticus superior muscle,* which arises by a tendinous expansion from the ligamentum nuchæ and from the spines of the seventh cervical and upper two dorsal vertebræ. The fibres pass downward and outward to be inserted by four fleshy slips into the second, third, fourth, and fifth ribs externally to their angles. This muscle is supplied by the second and third intercostal nerves and arteries. Its action serves to elevate the ribs. The *serratus posticus inferior muscle* is beneath the latissimus dorsi, which must be removed to expose it (Plate 83, Fig. 2, No. 27). It is larger than the *superior,* and arises from the lumbar fascia and from the spines of the two lower dorsal and two upper lumbar vertebræ, and, ascending outward, is inserted by four fleshy slips into the four lower ribs externally to their angles. It is supplied by the tenth and eleventh intercostal nerves and arteries, and by its action the ribs are depressed and fixed, thereby enlarging the thorax and enabling the action of the diaphragm to assist in expiration.

The lumbar fascia (or *aponeurosis*) (Plate 83, Fig. 2, No. 12) is the dense, glistening, white, fascial investment of the deeper muscles below the inferior serratus. It consists of three layers of fibres, an outer and an inner transverse and an intermediate vertical, and is attached to the spines of the lower dorsal and of all the lumbar and sacral vertebræ and the adjacent portion of the crest of the ilium. It also sends fascicles outwardly to the last two ribs and receives the attachment of the internal oblique muscle of the abdomen. In the upper portion of the back the fascia blends with the sheaths of the several muscles which originate there. The lumbar fascia forms a strong girdle about the loins, and ensheathes the **erector spinæ mass of muscles,** which are

PLATE 75.

Figure 1.

Antero-posterior median section through the male pelvis, penis, prostate gland, and urinary bladder, showing the relations of the parts about the neck of the bladder *in situ*.

1. The glans penis.
2. The fossa navicularis.
3. Section of the right corpus cavernosum close to the septum.
4. Supra-pubic fatty tissue.
5. Longitudinal section through the urethra in the spongy portion of the penis.
6. The dorsal vein of the penis.
7. Section through the symphysis pubis.
8. The triangular ligament.
9. The superior lobe of the prostate gland.
10. The membranous portion of the urethra.
11. The veru montanum, or caput gallinaginis.
12. The bulbous portion of the spongy portion of the urethra, covered with the accelerator urinæ muscle.
13. Position of the sub-urethral glands (of Cowper) within the inferior layers of the triangular ligament.
14. The inferior lobe of the prostate gland.
15. The right testicle, denuded of its scrotal coverings.
16. The promontory of the sacrum.
17. The vesico-abdominal reflection of the peritoneum.
18. The right wall of the bladder.
19. The orifice of the right ureter.
20. Section through the prostatic portion of the urethra and the neck of the bladder.
21. The prostatic plexus of veins.
22. Section through the rectum.

Figure 2.

Longitudinal section through the penis, urethra, and bladder, showing the relations of the parts as looked at from above.

1. The glans penis.
2. The fossa navicularis.
3. The corpus cavernosum of the left side.
4. The spongy portion of the urethra.
5. The left crus of the penis.
6. The membranous portion of the urethra.
7. Section through the left lobe of the prostate gland.
8. The openings of the prostatic ducts.
9. The trigonum vesicæ.
10. The orifice of the left ureter.
11. The fundus of the bladder.
12. The left ureter.
13. The corpus cavernosum of the right side.
14. The openings of the glands of Cowper.
15. The right crus of the penis.
16. Section through the right lobe of the prostate gland.
17. The sinus pocularis.
18. The veru montanum.
19. The orifice of the right ureter.
20. The right ureter.

Figure 3.

Transverse section through the middle of the penis.

1. The superficial vessels and nerves.
2. The deep vessels and nerves.
3. The right corpus cavernosum.
4. The corpus spongiosum.
5. The skin and superficial fascia.
6. The septum between the corpora cavernosa.
7. The left corpus cavernosum.
8. The urethra.

Fig 1

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Fig 2

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exposed upon its removal (Plate 84, Fig. 1). This consists of a large fleshy column occupying the groove on each side of the lumbar spines, and arises by short tendinous fibres from the posterior part of the iliac crest and tuberosity, from the sacro-iliac ligaments, and from the transverse processes and arches of the lumbar vertebræ, as well as by a superficial band from the spines of the sacral, lumbar, and lower two dorsal vertebræ. From this extensive origin the muscular fibres ascend to the level of the last rib, where they separate into three portions, the *spinalis dorsi*, the *longissimus dorsi*, and the *ilio-costalis*. The last two divisions are indicated by an intermediate groove which gives exit to the external cutaneous branches of the posterior spinal nerves and their accompanying vessels. The *spinalis dorsi* is the superficial portion of the erector close to the spinous processes. It arises by tendons, and, containing very few muscular fibres, is inserted into the upper nine dorsal spines by as many slips. It blends with the longissimus, and is continuous with the spinalis cervicis when that muscle is present. The *longissimus dorsi* is the largest portion of the mass. It is inserted into the transverse processes of all the dorsal vertebræ by rounded tendons, and into the lower borders of the lower eight ribs by fleshy slips between their tubercles and their angles. In the neck it is continued as the transversalis colli. The *ilio-costalis* (or *sacro-lumbalis*) consists of fibres which are arranged in a series of fascicles and ascend outwardly to be inserted by nine tendons into the angles of the lower nine ribs. These tendons are augmented by short accessory tendons derived from the lower ribs internally to their angles. In the neck the continuation is called the cervicalis ascendens. Beneath the erector spinæ mass are placed the *semispinalis* and *multifidus spinæ muscles*. The *semispinalis dorsi* arises by long delicate slips from the transverse processes of the lower four dorsal vertebræ, and is inserted into the spines of the upper four dorsal vertebræ. The *multifidus spinæ* is practically a part of the preceding muscle, although it is generally differentiated from it. It consists of a series of fascicles extending from the transverse processes of one vertebra to the spine of the vertebra above, from the sacrum to the second cervical vertebra. The largest are in the lumbar region.

Beneath the multifidus in the thoracic portion of the column there are usually demonstrable ten short transverse muscles, called the *rotatores spinæ.* They each arise from the posterior border of the transverse process of a dorsal vertebra and are inserted into the contiguous border of the lamina of the vertebra above. They serve to rotate the spine to one side or the other. There are also some weak bands of muscular fibres, found especially in the neck and loins, which are called the *intertransversales,* passing from the transverse process of one vertebra to that of another, and the *interspinales,* which extend between the spines on each side of the interspinous ligament. All the muscles of the back receive their nerve-supply from the posterior branches of the spinal nerves, which are exposed on removal of the semispinalis muscles. These nerves consist of *internal* and *external* branches, the former supplying the semispinales and deeper muscles and contributing cutaneous branches, while the latter mainly supply the erector group of muscles and also contribute cutaneous branches.

The action of the erector spinæ mass of muscles can be well shown when the erect position is slowly resumed after the body has been bent forward, especially if a heavy weight be lifted at the same time.

Upon removal of the multifidus spinæ muscles—a very tedious task—the *dorsal extra-spinal plexus of veins* is exposed. These veins are large, and form a complicated net-work around the spines and contiguous portions of the vertebræ, up and down the entire column. They receive the venous radicles which commence in the superficial fascia and the muscles of the back, and establish direct communications with the *intra-spinal veins* (page 191) by branches which perforate the interlaminar ligaments.

The spinal column consists of thirty-three irregular bony segments, the *vertebræ,* of which the upper twenty-four are separated during life by disks of fibro-cartilage, and are therefore called the *true* or *movable vertebræ,* in distinction from the lower nine, which are called the *false* or *fixed vertebræ,* because they become consolidated into the sacrum (page 107) and the coccyx (page 109). The true vertebræ are further designated according to the region of which they contribute the skeleton,—

the *cervical vertebræ* including the upper seven, the *dorsal* (or *thoracic*) *vertebræ* the succeeding twelve, and the *lumbar vertebræ* the lower five. All the vertebræ consist of two essential portions, an anterior cancellous bony disk, the *body*, or *centrum*, and a posterior compact bony arch, which is attached laterally to the posterior surface of each body. They are both variously modified in different localities to serve special purposes. The bodies are connected throughout the series by the intervertebral fibro-cartilages, which are attached to their upper and lower surfaces, and by strong elastic ligaments, forming a flexible support for the head and trunk, while the arches with their intervening ligaments form the protective *neural canal* which encloses the spinal cord.

The *bodies* generally are flattened above and below, presenting broad roughened surfaces with elevated rims at the circumference which project slightly in front and at the sides, where the middle portions are narrowed. The latter are also somewhat concave from side to side posteriorly, where they contribute to the formation of the neural canal. The front surfaces are perforated by several minute foramina for the passage of nutrient arteries, while behind there are one or two larger openings for the exit of veins from the cancellous structure (the *venæ basis vertebrarum*).

The *arches* present upon their convex surfaces seven variously-developed processes. Of these the *spinous processes* project backward in the middle line and are more or less conspicuous through the surface-tissues (page 174). The series of spinous processes are sometimes called collectively the *backbone*, or *spine*. Each of them has a pair of lateral ridges terminating in a tubercle, and a median ridge with a tuberosity. The *transverse processes* project outwardly on each side of the arches between the *articular processes*, of which there are four, two projecting upward and two downward, to join with similar processes on the contiguous vertebræ. The portions of the arches between the spinous and the articular processes are flattened, shelving, bony plates with roughened edges, the *laminæ*, and the strong rounded portions between the articular processes and the bodies are the *pedicles*. The intervals between the laminæ are filled in the natural state by short elastic ligaments, the

ligamenta subflava, and the pedicles are notched above and below, so that when they are in apposition they constitute the *intervertebral foramina*, which transmit the spinal nerves outward and the spinal arteries inward. There are also usually noticeable on each side of the arches a roughened surface posterior to the articular processes, the *tuberosity*, and upon the bodies, close to the pedicles, a *costal process*. The costal processes are short and rudimentary in the cervical and lumbar regions, while in the thoracic region they become the ribs.

Every vertebra of the series possesses characteristic features, but in each region there are some vertebræ whose peculiarities render them easily recognizable: thus, the cervical vertebræ have foramina in the costo-transverse processes for the vertebral arteries, the dorsal vertebræ have facets or demi-facets on the sides of their bodies for the articulation of the heads of the ribs, and the lumbar vertebræ are without either a foramen or a facet. These peculiarities are most conspicuous in the middle vertebræ of each region, while at the junction of the contiguous regions the adjoining vertebræ approximate one another in conformation.

The *cervical vertebræ* (Plate 1, Vol. I.) are the smallest and most delicately constructed of the entire column, and are especially adapted to the great mobility of the neck. The bodies are generally concave from side to side on their upper surfaces, owing to the elevation of their lateral borders, and concave from before backward, in consequence of the front border extending downward. The arches are broad but comparatively shallow, and the *spinal foramen* which they enclose is heart-shaped, gradually enlarging from the second to the fifth vertebra, and diminishing from the fifth to the seventh. The spinous processes vary very markedly, being wanting in the first cervical vertebra, large and strong in the second and seventh vertebræ, and small and bifid in the intermediate vertebræ. The laminæ are long and narrow, while the pedicles are directed backward and outward. The articular processes, situated at the junction of the laminæ and pedicles, have their surfaces directed upward and backward above, and downward and forward below. The transverse processes are not strongly developed, but are reinforced

by the costal processes, which extend from the sides of the body and join the transverse processes at their extremities by a bridge of bone, thus enclosing the *vertebral foramen.* The costal process in connection with the seventh vertebra is sometimes developed as a movable cervical rib.

The vertebræ in the cervical region which present especial features are the first, second, and seventh. The *first cervical vertebra* is called the *atlas,* because it supports the head. It has the appearance of a large bony ring, consisting of two *arches* joined by two broad *lateral masses,* its proper body having become separated and attached to that of the second vertebra, forming the odontoid process, which extends upward and is received against an oval facet upon the anterior arch of the atlas. On the front surface of the anterior arch there is a tubercle for the attachment of the longus colli muscles. The posterior arch is more delicately shaped than the anterior, but twice as long. On its back surface there is a rough, blunt tubercle, but no spinous process, because any such projection would interfere with the freedom of its rotation. The atlas is of greater breadth than any of the succeeding cervical vertebræ, and the *lateral masses* present on their upper surfaces irregular articular facets, which are variably constricted and have their outer borders raised for the reception of the condyles of the occipital bone, being adapted to the nodding movements of the head. Upon the under surfaces the articular facets are circular and slightly concave, being directed downward and inward, so that they enable the atlas to rotate readily upon the axis vertebra below. Below the inner border of each superior articular process there is a small tubercle for the attachment of the *transverse ligament,* which divides the ring of the atlas into two unequal parts, the anterior receiving the odontoid process, and the posterior being occupied by the spinal cord below the medulla oblongata. The costo-transverse processes extend farther outward than those of any of the other cervical vertebræ, for the attachment of muscles which assist in rotating the head. Through the foramina in these processes the vertebral arteries ascend, and, turning backward and inward, are accommodated upon grooves behind the lateral masses, which also transmit outward the first spinal or sub-occipital

nerves. These grooves are sometimes converted into foramina by the development of bony spiculæ arching across their borders.

The *second cervical vertebra* is called the *axis*, because it serves as a pivot upon which the head rotates. It is the strongest of the cervical vertebræ, and its most distinctive feature is the *odontoid process*, the detached and ankylosed body of the atlas. This process is attached to the occipital bone by two small *check ligaments* (the *occipito-odontoid*), and is prevented from pressing upon the upper part of the spinal cord by the transverse ligament in front of it. The pedicles, laminæ, and spinous process are remarkably strong: the latter presents a median ridge with short, depressed, lateral tubercles. The articular surfaces are modified to adapt them to the surfaces of the vertebræ with which they are in contact, and the costo-transverse processes are shorter and the vertebral foramina smaller than in the atlas.

The *seventh cervical vertebra* is called the *vertebra prominens*, because of the comparatively greater projection of its spinous process, which serves as a distinctive landmark in this region. In rare cases the costo-transverse process is perforated by a foramen for the vertebral artery (that vessel usually entering the foramen in the sixth vertebra), and in still rarer cases the development of a cervical rib occurs by the costal portion being segmented off.

The *dorsal*, or more properly *thoracic*, *vertebræ* are especially peculiar for the facets upon the sides of their bodies for the articulations of the ribs, and for the length and obliquity of their spinous processes. The bodies in the middle of the dorsal series are as broad from side to side as they are from front to back, and are characteristically heart-shaped. They are generally thicker and concave behind, and narrower and convex in front. On each side, near the root of the pedicle, there is a demi-facet above and below: these, when articulated with the adjoining vertebræ, form with the intervening disk of fibro-cartilage oval surfaces for the reception of the heads of the corresponding ribs. The pedicles are directed backward, and the laminæ overlap each other, the spinal foramen which they enclose being circular and smaller than in the cervical region. The articular processes are nearly vertical, and the costo-

transverse processes arise behind them. The latter are of considerable length, are strongly developed, and present clubbed extremities, their anterior portions having concave facets for articulation with the tubercles of the ribs. The first and twelfth dorsal vertebræ in general conformation approximate respectively the last cervical and first lumbar vertebræ.

The dorsal vertebræ which have noteworthy differences are the first, second, ninth, tenth, eleventh, and twelfth. The *first dorsal vertebra* has a single facet on each side of the body for the reception of the head of the first rib, and a demi-facet below for the upper half of the head of the second rib. In other respects it resembles the vertebra prominens. The *second* is peculiar in that the pedicles occupy a higher plane than the upper surface of the body when the vertebra is in position. The *ninth* has a costal facet on its pedicle above, but is without any on its body below. The *tenth* has a single facet on its upper border, and a small one on the upper surface of the transverse process. The *eleventh* has a facet on its pedicle only. The *twelfth* has a facet near the lower border of its pedicle, and the inferior articular processes are convex outward, resembling those of the lumbar vertebræ. The transverse processes are shorter and trifid, ending in the superior, inferior, and external tubercles.

The *lumbar vertebræ* are the largest segments of the entire vertebral column. Their bodies are more constricted in the middle and have their margins more prominent, although in other respects like the bodies of the thoracic region. The arches are relatively less deep, there being considerable intervals between the laminæ of the neighboring vertebræ upon each side. The spinal foramen is larger than in either of the upper regions, and of triangular shape. The spinous processes are broad and thick vertical projections, terminating in rough lateral tubercles below. The superior articular processes are concave and directed inward, while the inferior are convex and directed outward and forward. The transverse or costal processes are long and slender, and are placed in front of the articular processes instead of behind them, as in the dorsal vertebræ. The superior tuberosities are connected with the superior articular processes, and appear as rounded knobs (the *mammillary*

PLATE 76.

Figure 1.

Antero-posterior section of the pelvis with the viscera removed to show the femoral opening or ring on the right side and the branches of the internal iliac artery, and especially the usual course of the obturator vessels and nerve. (From a female aged twenty-three.)

1. The deep circumflex iliac artery and veins.
2. The deep epigastric artery and veins.
3. The external iliac artery.
4. The external iliac vein.
5. The femoral opening or ring.
6. The lunated edge of Gimbernat's ligament.
7. The inferior vesical and middle hæmorrhoidal arteries.
8. The internal pudic artery.
9. The sciatic artery.
10. Section through the symphysis pubis.
11. The common iliac vein.
12. The common iliac artery.
13. The internal iliac artery.
14. The upper cord of the sacral plexus of nerves.
15. The internal iliac vein.
16. The superior vesical artery.
17. The obturator nerve.
18. The obturator artery.
19. The gluteal artery.
20. The obturator vein.
21. Lateral sacral artery.
22. The middle cord of the sacral plexus.
23. The lower cord of the sacral plexus.
24. The great sacro-sciatic ligament.

Figure 2.

Transverse section of the pelvis, to show the occasional origins of the obturator artery from the epigastric and their various relations to the femoral opening: of importance in the operation for femoral hernia. (From a female aged twenty-seven.)

1. Gimbernat's ligament upon the left side, and the femoral opening.
2. The left deep epigastric artery.
3. The left deep circumflex iliac artery.
4. The external cutaneous nerve.
5. The left obturator artery curving along the edge of Gimbernat's ligament.
6. The anterior crural nerve.
7. Section through the left innominate bone.
8. The right femoral opening, showing well Gimbernat's ligament.
9. The right deep epigastric artery.
10. The right deep circumflex iliac artery.
11. The right external cutaneous nerve.
12. The right obturator artery, passing in immediate relation to the external iliac vein.
13. The right anterior crural nerve.
14. Section through the right innominate bone.

Figure 3.

The superficial dissection of the male perineum, showing the deep fascia (of Colles) covering the urethral region, the fatty tissue occupying the ischio-rectal region, and the external sphincter ani muscle.

1. The scrotum.
2. The deep layer of the superficial fascia covering the urethral region.
3. The fascia lata.
4. The tuberosity of the ischium on the right side.
5. The external sphincter ani muscle.
6. The right gluteus maximus muscle.
7. The skin and superficial layer of the superficial fascia reflected.
8. The central tendon of the perineum.
9. The superficial fascia and fat in the left ischio-rectal fossa.
10. The anus.
11. The left gluteus maximus muscle.
12. The ano-coccygeal ligament.

Fig 1

Fig 2

5.
6.
7
8
9
10

Fig 3

processes), and the inferior tuberosities point downward from the bases of the transverse processes, and are called *accessory processes.* The latter are pronounced in some of the lower animals, and serve to lock the vertebræ in this region very closely. The fifth lumbar vertebra is different from its fellows in having the body much thicker in front than behind, forming, when articulated with the sacrum, the *sacro-vertebral promontory*, and in approaching in character the upper sacral vertebra in the great size of its transverse processes and in the wide interval between the inferior articular processes.

In the embryo about the sixth or seventh week the vertebral column becomes first developed as a cartilaginous framework for the succeeding *centres of ossification*, of which there are usually three for each typical vertebra,—one for the body and two for the lateral portions of the arch. The deposit of bone begins about the fortieth day in the neural arch of the first vertebra and proceeds gradually downward in the arches of the vertebræ below in successive order; while in the bodies it begins at the middle of the column (the ninth dorsal vertebra) about the forty-eighth day, and extends upward and downward. Ossification is more rapid in the arches than in the bodies, and the lines of junction which they form with the bodies (the *neuro-central sutures*) usually become obliterated between the third and sixth years. In consequence of the process naturally extending from above downward, arrest of development is most apt to occur in the lumbar or the sacral region, and the neural canal, not being closed posteriorly, may allow the membranes of the cord with the cerebro-spinal fluid to bulge outward in the middle line as a soft tumor beneath the skin, called *spina bifida.* It is possible that this affection is caused by an excessive secretion of the cerebro-spinal fluid in the early development, which prevents the coalescence of the lateral portions of the neural arches. The various processes are progressively developed from secondary ossific centres usually arising in their respective positions.

The bodies of all the movable vertebræ are united by the interposition of the *disks of intervertebral fibro-cartilage*, of which there are twenty-three, forming fourteen centimetres, or about five and a half

inches, of the length of the entire vertebral column in a man of average stature. Each disk consists of outer concentric layers of fibro-cartilage (*annulus fibrosus*), surrounding a pulpy nucleus (*nucleus pulposus*), which resembles a synovial sac. The nucleus is not quite in the centre of the fibro-cartilage, and contains a small irregular-shaped cavity. The superficial fibres at the circumference are vertical, while those of the deeper layers cross one another, taking an oblique direction from side to side, and contain cartilage-cells in their interspaces. The smallest of the disks is between the fifth and sixth cervical vertebræ, from which they gradually enlarge downward. In the cervical and lumbar regions the disks are all higher in front than they are behind, and in the dorsal region they are somewhat higher behind than in front. The lumbo-sacral disk is peculiarly ridge-shaped, being nearly twice as high in front as the disks above it.

The entire column, composed of the vertebral bodies and disks of fibro-cartilage, is ensheathed with a continuous layer of white fibres, intimately associated with the periosteum, which, owing to its greater thickness in front and behind, is specialized into two bands, called the *anterior* and *posterior common ligaments.* The anterior commences at the anterior tubercle of the atlas, between the longus colli muscles, and descends along the front of the column to the coccyx. This ligament consists of several layers, the outer, composed of long fibres, extending over several vertebræ, and the inner, of short fibres, from one vertebra to another. It is thicker over the bodies of the vertebræ than the intervertebral disks. The posterior ligament is within the neural canal, extending from the anterior border of the foramen magnum to the sacrum, and being attached to the posterior surfaces of the vertebral bodies and the disks throughout its course. It has a scalloped appearance when examined in its entire length, owing to its being narrowed and thinned opposite the middle of each vertebral body for the exit of the venæ basis vertebrarum. It also consists of several layers, the fibres of which are disposed similarly to those of the anterior ligament.

The *interlaminar ligaments* (or *ligamenta subflava*) fill the intervals between the neural arches. They are thick bands of pure yellow elastic

fibres, attached to the roughened edges of the opposing laminæ above and below. They are continuous from side to side, uniting beneath the spinous processes and giving origin to the *interspinous ligaments.* These consist of double layers of horizontal white fibres extending from the median ridge of each lower spine to the inter-tuberous space of the spine above. They are variably developed in different localities, being especially weak in the neck. The *supra-spinous ligament* consists of a longitudinal continuous band extending along the series of spinous processes. It is inseparable from the lumbar fascia, and is specialized in the dorsal region as the *ligamentum apicum,* and in the neck as the *ligamentum nuchæ.* The special ligaments concerned in the articulation of the skull with the upper two cervical vertebræ, and in the articulation of the ribs with the dorsal vertebræ, are described in Vol. I.

The average length of the vertebral column in the well-formed adult male is about sixty-nine centimetres, or twenty-seven and three-fourths inches, and in the female sixty-seven and a half centimetres, or twenty-seven inches. When viewed from the side the bodies are seen to increase in size from above downward, forming an elongated cone, and when in the erect position the line of the centre of gravity passes through the column from the odontoid process through the front of the body of the second dorsal, the middle of the twelfth dorsal, and the border of the last lumbar vertebra.

At birth the infant's spine is quite straight, serving merely to connect the head, limbs, and ribs, and as a protecting column to the spinal cord. It is very flexible at this time, and totally without the important factors of gravity and muscular contraction which, as the child begins to sit and stand and walk, tend to produce the characteristic curvatures in the neck, back, and loins. These curvatures are not fully developed until adult life; and, as the spinal column owes to them its elasticity and power of withstanding various forces communicated to it, they are deserving of special attention. In the back of a young child, especially if it be delicate or the subject of rickets, there will always be noticed a general curving of the column backward. In fact, this convex curvature of the back is that which persons naturally assume when feeble

or weary at any period of life, and habit or occupation often makes it very pronounced. The dorsal curvature and the pelvic curvature, made up of the sacro-coccygeal vertebræ, are the natural ones found in the infant. In the embryo, at the very beginning of the formation of the column it assumes this dorsal convexity, and as soon as the sacral promontory is developed it is modified only by the addition of the pelvic curve. The normal curvatures of the spine are maintained to a great extent by the disks of intervertebral fibro-cartilage, which are most developed in the regions where most movement is allowed. The disks act as buffers in resisting shocks, and contribute very much to the elasticity of the spine. The natural curves are all antero-posterior, with a very slight deviation to the right in the thoracic region, as already stated (page 174). The erector spinæ mass of muscles occupy the gutters upon either side of the spinous processes, and, being inserted into the spines and the transverse processes, tend to establish equilibrium. The motions which the muscles are capable of exerting upon the spinal column are lateral, antero-posterior, and rotatory. The greatest degree of rotation and lateral flexion is found in the neck and loins. Structural changes and unequal muscular exercise produce deformity. When the curvatures are exaggerated they are called *cyphosis*, *lordosis*, and *scoliosis*, according as the convexity is directed backward, forward, or laterally. The first deformity, or cyphosis, is seen in rickets or in caries of the bodies of the vertebræ (*i.e.*, Pott's disease). The lordosis, or saddle-back, is produced very often by inflammation of the hip (as in coxalgia), and the scoliosis, which is the most frequent, is generally met with among young people who assume vicious attitudes. It is an invariable rule with regard to spinal deformities that if a weakness occurs at any point which occasions deviation there will arise compensating deviations above or below it. In marked cases there will also occur a rotatory curvature, caused by the contraction of the slips of the longissimus dorsi muscles which are attached to the angles of the ribs. This is sometimes so powerful that the transverse processes are twisted into the usual position of the spines. The most frequent seat of lateral curvature is about the fourth or fifth dorsal vertebra.

The weakest part of the column is between the second and third cervical vertebræ. The most movable part is at the junction of the twelfth dorsal and first lumbar vertebræ, and here the back is most liable to injury from strain. There is very slight motion between any two vertebræ, but the degree of movement resulting from the sum of the motions between the contiguous vertebræ of the series is considerable, and variable in different individuals. It can be increased by early acrobatic training to an almost incredible degree, as is seen in contortionists, who can bend the spine backward so that the head can be brought forward between the thighs. The weight of the head and upper extremities increases the convexity of the back, and compresses the intervertebral disks, so that at night the ordinary stature of the adult is diminished about thirteen millimetres, or half an inch, from what it was on rising in the morning.

When the arches of all the vertebræ are removed by sawing through the laminæ close to the articular processes, the membranes of the spinal cord will be found embedded in loose connective tissue containing a quantity of reddish-colored fat and more or less serous fluid. The space between the outer fibrous sheath or dura mater of the cord and the neural arches of the column is the *extra-dural space*, and contains a remarkable plexus of large and tortuous veins, supported within the meshes of the cellular tissue.

These veins constitute the *dorsal intra-spinal plexus of veins*, and receive the communications from the extra-spinal plexus above referred to. Within the spinal canal there are two pairs of longitudinal vein-trunks, called, from their situation, the *posterior* and *anterior longitudinal spinal veins*, the posterior pair being in relation to the laminæ on each side, and the anterior pair on each side of the posterior common ligament which extends over the bodies of the vertebræ throughout the length of the column (page 188). These longitudinal veins are connected by transverse links, which bring them all into direct communication. Between the two posterior longitudinal veins the transverse branches extend across the interlaminar ligaments, and between the two anterior longitudinal veins the transverse branches cross over the backs of

the vertebral bodies, and are comparatively larger, because they receive the blood from the veins of the cancellous structure of the bodies of the vertebræ, which issue by two foramina and are called the *venæ basis vertebrarum.* Furthermore, there are lateral transverse veins on the inner side of the vertebral pedicles, which connect the posterior and anterior longitudinal veins of the same side and thus complete a system of venous rings in relation to each vertebral segment. All the above veins are situated between the spinal canal and the dura mater of the cord, and are therefore called the *meningo-rachidian veins.* They are larger in the dorsal and lumbar portions of the column than they are in the cervical portion, and they communicate in the several regions with the vertebral, intercostal, lumbar, and sacral veins by branches, the *rami spinales,* which make their exit through the intervertebral foramina. There are no valves in any of the spinal veins, and they are therefore liable to become congested in diseases of the spine. It has been inferred that owing to this fact much benefit may be derived from the treatment by suspension in such diseases, whereby the stasis in the veins of the cord is relieved.

The dura mater of the spinal cord is continuous with the dura mater of the brain (Plate 4, Fig. 2, Vol. I.), but it is attached to the bone only at the margin of the foramen magnum, and by loose slender connective tissue to the posterior common ligament (page 188), so that there are no intra-spinal adhesions which would hinder the easy movements of the vertebræ upon one another. The cord does not occupy the whole cavity of the spinal canal, being separated from the inner surfaces of the vertebral arches by the contents of the extra-dural space above described. When the dura mater is completely exposed, it appears as a tough fibrous membrane, the *theca vertebralis,* enveloping the cord as far as the second bone of the sacrum, whence it continues as a narrow fibrous string to the coccyx, blending with the periosteum. It is relatively larger in the cervical and lumbar portions of the spine corresponding to the origins of the spinal nerves which respectively form the brachial and lumbar plexuses of nerves in these localities. Upon each side there are rows of double openings near the intervertebral and sacral

foramina, which give exit to the anterior and posterior roots of the spinal nerves, about which the membrane is prolonged as far as the foramina, where it blends with the periosteum.

The structure of the dura mater of the cord consists of white fibrous tissue interwoven with a considerable amount of elastic tissue, and therefore unlike the corresponding membrane of the brain. It is somewhat thicker behind than in front, and both its internal and external surfaces are lined with a delicate layer of epithelium. It is supplied by very fine meningeal branches of the spinal arteries, which may sometimes be seen, when the vessels are well injected, ramifying upon the outer surface like little tendrils. The veins terminate in the plexus of spinal veins, and a few nerve-filaments have been traced upon it. When the dura mater is slit open, it will be seen that it does not send prolongations into the substance of the cord which it contains, but forms a distinct loose sheath. The internal surface is more or less connected with the delicate **arachnoid membrane**, which is a continuation of the arachnoid membrane of the brain. This is reflected over the spinal nerves as they pass to the openings in the dura mater, and closely invests the cord, the pia mater being interposed between them. The interval between the dura and the arachnoid is known as the *sub-dural space*, in contradistinction to that between the arachnoid and the pia mater, which is the *sub-arachnoidean space*. These spaces are now regarded as *lymph-spaces*. In both, during life, there is a secretion of transparent serous fluid, the *cerebro-spinal fluid:* this is more abundant, however, within the sub-arachnoidean space, which is directly continuous with the similar space within the membranes of the brain, the *spinal fluid* being the same as and communicable with the fluid within the general ventricular cavity of the brain through the *foramen of Magendie*, the opening in the inferior boundary of the fourth ventricle, as previously described (page 50, Vol. I.). Cases of *spina bifida* afford an actual demonstration of the communication of the cerebro-spinal fluid, for when a child who possesses this condition of malformation coughs or cries, the fluid within the cerebral ventricles appears to be momentarily forced into the meningeal tumor of the spine. The amount of fluid normally contained within

PLATE 77.

Figure 1.

The deep perineal fascia is reflected from the urethral region to show the intermuscular triangles, the superficial perineal vessels and nerves, and the perineal surface of the triangular ligament; the fat is also removed from the ischio-rectal fossæ, exposing the levator ani muscle on the right side and the inferior rectal vessels and nerves on the left.

1. The handle of a staff introduced into the urethra.
2. The cut margin of the superficial fascia.
3. The right corpus cavernosum.
4. The corpus spongiosum.
5. The fascia lata.
6. The accelerator urinæ muscle.
7. The deep perineal fascia reflected.
8. The erector penis, or ischio-cavernosus muscle.
9. The anterior layer of the triangular ligament.
10. The superficial transverse perineal muscle.
11. The deep perineal fascia reflected.
12. The right gluteus maximus muscle.
13. The levator ani muscle.
14. The external sphincter ani muscle.
15. The anus.
16. The attachment of the sphincter ani muscle to the coccyx by the ano-coccygeal ligament.
17. The median raphé of the scrotum.
18. The margin of the incision through the skin and superficial fascia.
19. The left corpus cavernosum.
20. The left adductor magnus muscle.
21. The superficial perineal vein, artery, and anterior perineal nerve.
22. The inferior pudendal nerve.
23. The left semi-tendinosus muscle.
24. The superficial perineal vessels and nerve.
25. The fascia lata over the tuber ischii.
26. The triangular ligament.
27. The central tendinous point of the perineum.
28. The transverse perineal artery, vein, and nerve.
29. The gluteus maximus muscle.
30. The internal pudic artery, vein, and nerve.
31. The inferior hæmorrhoidal vessels and nerve.
32. The margin of the left gluteus maximus muscle.
33. The great sacro-sciatic ligament.
34. The fourth sacral nerve.

Figure 2.

The muscles of the urethral region are removed to show the relations of the crura of the penis and the deeper vessels to the bulb of the spongy portion of the urethra, and the position of the sub-urethral glands (of Cowper) in relation to the deep layer of the triangular ligament.

1. The handle of a staff introduced into the urethra.
2. The fascia lata over the right gracilis and adductor magnus muscles.
3. The corpus spongiosum.
4. The right crus of the penis.
5. The ischio-cavernosus artery.
6. The bulb of the spongy portion of the urethra.
7. The right sub-urethral, or Cowper's, gland.
8. The right tuber ischii, covered with the fascia lata.
9. The levator ani muscle.
10. The right great sacro-sciatic ligament.
11. The right gluteus maximus muscle reflected.
12. The cut margin of the superficial fascia.
13. The left adductor magnus muscle.
14. The inferior pudendal nerve.
15. The left crus of the penis.
16. The left semi-tendinosus muscle.
17. The dorsal artery of the penis.
18. The artery of the bulb.
19. The bulb of the spongy portion of the urethra.
20. The position of the membranous portion of the urethra.
21. The left superficial hæmorrhoidal vessels and nerve.
22. The anus.
23. The left great sacro-sciatic ligament.
24. The left gluteus maximus muscle.
25. The coccygeal tendon of the sphincter ani muscle.

Fig 1

Fig 2

[illegible] graphed and Co[illegible] from Nature by George Mc Clellan M D

the sub-arachnoidean space of the cord is probably about an ounce. It undoubtedly serves the important purpose of subduing the effects of shock upon the cord from external violence.

Beneath the arachnoid membrane is the **pia mater of the cord,** which does not correspond to the similar membrane of the brain except in its relative position. It is not so much a supporting tissue for the blood-vessels as it is for the nerve-centre itself, being altogether stronger, more fibrous in structure, and more adherent to the tissue of the cord. It is prolonged within the anterior and posterior median fissures of the cord, and forms the neurilemma or proper sheath of each of the spinal nerves. The *veins of the spinal cord* form a fine, tortuous plexus in the meshes of the pia and open into the intra-spinal plexus by branches which accompany the nerves to the intervertebral foramina. The pia mater appears thickened in front, and extends along the anterior median fissure as a white, glistening band, the *linea splendens* (*of Haller*). Laterally the pia mater constitutes the *ligamentum denticulatum,* partially separating the anterior and posterior roots of the spinal nerves by fibrous processes which extend from the cord to the inner surface of the dura. These processes appear pointed at their dural insertions. They are arranged in a series of about twenty upon each side of the cord, which they serve in a measure to support within the spinal fluid during the movements of the spinal column. The latter function is also maintained by the downward prolongation of the pia mater from about the level of the second lumbar vertebra, where the cord terminates. This prolongation is called the *filum terminale,* or central ligament. It passes through the cauda equina to the top of the sacral canal, where it blends with the dura and continues to the coccyx. The pia is composed of longitudinally-arranged connective- and elastic-tissue fibres. It is provided with filaments from the posterior roots of the spinal nerves and from the sympathetic nerve.

The spinal cord (*medulla spinalis*) is the continuation of the medulla oblongata within the vertebral canal (Plate 85). It is forty-five centimetres, or about eighteen inches, in length, and varies in weight in different individuals, averaging about an ounce and a half, being

somewhat lighter in the female than in the male. It extends downward to the lower border of the first lumbar vertebra, where it terminates in the *conus medullaris*, from which the roots of the nerves arise upon each side, forming a leash or bundle of nerve-cords called the *cauda equina*, in the midst of which, posteriorly, is the *filum terminale*, the prolongation of the pia mater of the cord above described. In the female the spinal cord usually terminates at the second lumbar vertebra. Looked at *in situ* (Plate 85), it is noticeable that the cord does not fill the vertebral canal, and that it is not of uniform size, being enlarged between the second cervical and the first dorsal vertebra, forming the *cervical* or *brachial enlargement*, and between the eleventh dorsal and the first lumbar vertebra, forming the *lumbar enlargement*. The transverse measurements of the cord are, in the cervical enlargement opposite the disk between the fifth and sixth cervical vertebræ about thirteen millimetres, throughout the dorsal or thoracic region about ten millimetres, and in the lumbar enlargement opposite the twelfth dorsal vertebra about twelve millimetres. The antero-posterior measurement averages about eight millimetres.

When viewed in position, it will be noticed that the connections of the cord consist of, besides its upward continuation into the brain through the medulla oblongata, the roots of the spinal nerves, which pass out laterally from it and leave the vertebral canal through the intervertebral foramina. If the finger be carefully inserted from either side between any two of the pairs of roots of the spinal nerves, it will be found that the cord is connected with the theca along the position of the anterior fissure by the linea splendens, and that its anterior surface can be thus explored while in position.

The spinal cord when removed from the vertebral canal is found to be partially divided by longitudinal fissures in front and behind which nearly reach its centre. The *anterior median fissure* is the widest, and extends through about one-third of the substance of the cord to a transverse layer of white tissue called the *anterior white commissure*, which connects the anterior portions of the two halves of the cord. The *posterior median fissure* is less distinct upon the surface than

the anterior, but extends deeper through about one-half of the substance of the cord to the *posterior gray commissure.* There is also upon each side a *posterior lateral groove* or *fissure,* which corresponds to the line of entrance of the posterior roots of the spinal nerves, and extends to the posterior cornu of the gray matter in the interior of the cord; and an *anterior lateral groove* or *fissure* (not well marked), which indicates the line of emergence of the anterior roots of the spinal nerves. By means of these fissures the external white portion of the cord is marked out into anterior, lateral, and posterior tracts or columns on each side, which are respectively continuous with the corresponding anterior pyramid, the lateral tract, and the restiform body of the medulla oblongata (page 45, Vol. I.). The posterior column upon each side of the posterior median fissure is subdivided by an intermediate furrow (the *sulcus intermedius posticus*) into two slender white bands, which are respectively called the *inner* or *posterior median column* (*of Goll*) and the *outer* or *posterior lateral column* (*of Burdach*), and which are continuous with the posterior pyramid above. Both extend through the whole length of the cord.

The structure of the cord can be best understood from horizontal sections at various levels, from which it will be found to be nearly solid, being composed of white substance externally enclosing gray matter internally and surrounding a fine *central canal* (or *ventricle of the cord*), which extends from the fourth ventricle of the cerebellum above through the entire cord to the conus medullaris below.

The *gray matter* in any transverse section has somewhat the form of the outspread wings of a butterfly, owing to its being disposed in two curved masses, the convex borders turned toward each other and connected in the centre by a narrow band constituting the gray commissure. Each curved mass has *anterior* and *posterior cornua,* or *horns,* which in shape may be compared to the front and back wings of the insect. The *anterior cornua* are broader but less wide-spread than the posterior, and project toward the lines of emergence of the anterior roots of the spinal nerves, while the *posterior cornua* are narrower, wider apart, and project to the posterior lateral grooves occupied by the posterior nerve-roots.

In the cervical and upper dorsal regions there are additional projections between the anterior and posterior cornua on each side, which extend outward opposite the gray commissure. They are called the *lateral cornua*, or *intermedio-lateral tracts*, and their fibres have been traced through the medulla oblongata. At other parts of the cord—*i.e.*, the upper cervical, the lower dorsal, and especially the lumbar enlargement —there are other projections of the gray matter noticeable on the inner side of the neck of each posterior cornu and just behind the gray commissure. These are called the *visceral columns* (*of Clarke*). The cornua of the gray matter can be distinguished in a horizontal section of any part of the cord above the conus medullaris, in which the gray matter is arranged in a central mass without horn-like projections, and interrupted only by the continuation of the anterior and posterior median fissures. On the conus the surrounding white matter gradually diminishes, and disappears altogether at the filum terminale.

Upon examining a transverse section of the middle of the cord, it will be noticed that the posterior cornua are constricted at their junction with the anterior cornua. This is called the neck, or *cervix cornu*, which first enlarges, forming the head, or *caput cornu*, and then dwindles to a point, the *apex cornu*. It should be remembered, however, that these horn-like divisions of the gray matter are really sections of gray columns extending the entire length of the cord. They present variations in structure and relative size at different points. The anterior cornua are generally shorter, as well as broader, and approach the anterior nerve-roots, but do not reach the surface of the cord. They are largest in the cervical and lumbar regions, and smallest in the thoracic region. The posterior cornua are generally narrower at the neck, and the enlarged portion, or head, is surrounded by a semi-transparent gelatinous material, the *substantia gelatinosa*, which extends to the surface about the entrance of the posterior nerve-roots. In the lumbar region they become considerably broader.

In the cervical enlargement the anterior and lateral cornua emerge, forming one anterior lateral mass; and on the outer borders of the posterior cornua behind the lateral cornua there is a net-work of white

and gray fibres, the *formatio reticularis spinalis,* which gives to the cord in this position a reticular appearance.

The minute anatomy of the spinal cord.—The gray matter consists of a structure called the *substantia spongiosa,* composed of nerve-cells embedded in a matrix of connective tissue, the *neuroglia* (*of Virchow*), and traversed by bundles of medullated nerve-fibres passing in different directions, interspersed with minute blood-vessels. The *cells of the anterior cornua* or *columns* are mostly large and multipolar, and are arranged in groups in the various portions of this part of the cord. They are classified as an *internal group,* which gradually decreases toward the lumbar region, an *anterior group,* and an *antero-lateral group,* both of which are combined into one in the cervical enlargement, and a *postero-lateral group,* which is usually distinct throughout the length of the cord. Many of the medullated nerve-fibres are connected by their axis-cylinders with the nerve-cells, and then become associated into bundles which ultimately form the anterior roots of the spinal nerves. Some of the nerve-cells are brought into relation with the anterior nerve-roots of the opposite side through the transverse nerve-fibres of the anterior commissure, near which they are situated. The cells of the lateral cornua are also multipolar, but smaller than in the anterior cornua. In the thoracic region they are large toward the anterior cornua and small toward the posterior cornua. The cells of the visceral column are notably smaller, and give off few processes. In the posterior cornua the cells are generally very small and fusiform. They are interwoven with numerous fine medullated nerve-fibres which enter from the posterior roots of the spinal nerves, but give off very few axis-cylinder processes.

The *gray commissure* consists chiefly of transverse medullated nerve-fibres in a matrix of neuroglia. The fibres upon reaching the lateral curved masses of gray matter diverge at various angles into the cervix cornu, some being continuous with the posterior nerve-roots. The central canal within this commissure is enclosed by a layer of the neuroglia which is free from nerve-fibres. This canal is lined with ciliated epithelium in infancy, but in later life appears filled with small polyhedral cells.

Sometimes the canal appears in dissections to communicate at the lower part of the conus by a small cleft with the posterior median fissure; but this cannot always be demonstrated.

The *white substance* forms the greater portion of the cord, and is situated externally to the gray matter. It is destitute of nerve-cells, and composed almost wholly of longitudinal medullated nerve-fibres, except in the white commissure, where the fibres are transverse, and in the anterior roots of the spinal nerves, where they are oblique. The white commissure is formed of fibres extending from the anterior cornu of gray matter upon one side to the white substance of the anterior column of the opposite side. The nerve-fibres of the white substance are supported by neuroglia with minute blood-vessels ramifying within its meshes. Upon transverse section of the white substance the axis-cylinders of the nerve-fibres appear like little dots, the white area about them being the *substance of Schwann.* Throughout the neuroglia the microscope reveals many branched connective-tissue cells or neuroglia-cells, but, as above stated, no nerve-cells. The longitudinal nerve-fibres of the white substance are arranged in bundles, which constitute the anterior, lateral, and posterior columns or tracts, and which are more or less distinctly indicated upon the surface by the different fissures (page 196).

The very complicated courses of the nerve-fibres of the spinal cord to and from the medulla oblongata and thence to the brain have been most laboriously studied, and there is much yet to be determined regarding them. From delicate and careful dissection, from experiment, and from observation of pathological changes, a great deal has been learned, and the following description is now generally accepted by histologists, but will doubtless be modified by future researches.

There are essentially two series of fibres in the anterior columns, an internal set, called the *direct pyramidal tract* (*of Türck*), which have not yet been satisfactorily traced, the descending fibres of which are now believed to cross from one side through the white commissure to terminate in the cells of the anterior cornu of the gray matter of the opposite side, and an external set, consisting of fibres descending from the medulla oblongata to the anterior roots of the spinal nerves. The

lateral columns are very much larger than either the anterior or the posterior columns, and their component fibres are exceedingly complex. They are subdivided into *antero-lateral* and *mixed lateral tracts*, which consist of fibres closely resembling those of the external set of the anterior column, commingled with some fibres from the posterior nerve-roots. A special bundle of fibres which pass through the formatio reticularis forms the *internal mixed lateral tract*, and is situated between the antero-lateral tract and the corresponding anterior cornu of gray matter. To the outer side of the internal mixed lateral tract, and separated by it from the posterior horn of gray matter, is the *crossed pyramidal tract* or *column* (*of Türck*), the fibres of which have been traced descending from the opercular lobe through the anterior portion of the internal capsule (page 54, Vol. I.) and through the crusta of the crus cerebri on each side into the corresponding anterior pyramid of the medulla oblongata, where they cross from one side to the other and eventually pass out from the cord below at variable points in the anterior roots of the spinal nerves. These fibres in the pyramidal part of their course are in close association with the fibres of the direct pyramidal tract of the anterior column of the cord.

There is good reason to believe that these fibres convey voluntary impressions, and that therefore the *anterior roots* of the spinal nerves are their *motor roots*. In the upper half of the cord there is a thin layer of white fibres upon the outer surface of the crossed pyramidal tract, to which the special name of *cerebellar tract* is given, because its fibres are traceable into the cerebellum and the restiform body of the medulla oblongata. The cerebellar tract is now believed to be connected with the visceral column (of Clarke). The *column of Goll* and the *column of Burdach* have already been described as being formed by the interposition of the intermediate furrow upon each side of the posterior median fissure. The fibres of the former apparently ascend from the posterior roots of the spinal nerves to the funiculi graciles in the floor of the fourth ventricle, while those of the latter ascend to the restiform body. The effect of lesions of these nerve-fibres has confirmed the inference that they are the *sensory roots*.

PLATE 78.

Figure 1.

The levator ani muscle is separated from its insertion and its lateral attachment, and the rectum (distended) is drawn outward and aside to show the position of the prostate gland.

1. The handle of a staff introduced into the urethra.
2. The scrotum.
3. The right corpus cavernosum.
4. The fascia lata.
5. The bulb of the spongy portion of the urethra.
6. Cowper's glands.
7. The prostate gland.
8. The right gluteus maximus muscle reflected.
9. The rectum drawn outward and to the right side.
10. The right great sacro-sciatic ligament.
11. The coccyx.
12. The left corpus cavernosum.
13. The left adductor magnus muscle.
14. The membranous portion of the urethra.
15. The superficial perineal vessels.
16. The internal pudic artery, vein, and nerve.
17. The left gluteus maximus muscle.
18. The left great sacro-sciatic ligament.

Figure 2.

The rectum (emptied) dissected from the recto-vesical fascia and drawn outward to show the prostate gland, seminal vesicles, and the vesico-prostatic plexus of veins at the base of the bladder; also the relation of the peritoneum to the perineum.

1. The right crus of the penis.
2. The fascia lata.
3. The gland of Cowper on the right side, with the artery of the bulb.
4. The prostate gland.
5. The cut levator ani muscle.
6. The base of the bladder.
7. The seminal vesicle of the right side.
8. The right internal pudic vessels and nerve.
9. The reflected right gluteus maximus muscle.
10. The rectum dissected away from the bladder and drawn outward.
11. The scrotum.
12. The left crus of the penis.
13. The bulb of the spongy portion of the urethra.
14. The artery of the bulb on the left side.
15. The membranous portion of the urethra.
16. The fascia lata over the left tuber ischii.
17. The cut edge of the levator ani muscle.
18. The vesico-prostatic plexus of veins.
19. The seminal vesicle of the left side.
20. The left gluteus maximus muscle.
21. The recto-vesical fascia reflected.
22. The left great sacro-sciatic ligament.
23. The left vas deferens.
24. The trigonum vesicæ.
25. The peritoneum.
26. The middle hæmorrhoidal artery.

Fig. 1

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Dissected, Photographed and Colored from Nature by George Mc Clellan M.D.

The white substance is invested with the pia mater and a layer of neuroglia, which penetrate from the surface to a variable extent by the fissures, and from which are formed the *supporting structures.* These not only fill the intervals between the nerve-fibres, but also convey the minute *sulcine arteries* (branches of the various spinal arteries) throughout the tissue of the cord.

The spinal cord is very vascular, and its arteries anastomose freely with one another, instead of terminating in blind extremities or end-arteries like the arteries of the brain (page 22, Vol. I.). The arteries of the cord are derived from the vertebral, ascending cervical, intercostal, and lumbar arteries, which enter the vertebral canal through the intervertebral foramina and form the *anterior, lateral,* and *spinal arteries.* These vessels all establish anastomoses with corresponding branches from the opposite side in the meninges of the cord, and respectively send branches into the substance of the cord through the different fissures which supply the special portions of the gray matter and anastomose with one another. There are two *veins* in the gray commissure surrounding the central canal which communicate with veins in the anterior and posterior median fissures, tributaries of the spinal veins.

From each side of the spinal cord **thirty-one pairs of spinal nerves** arise and pass outward through the intervertebral foramina, as follows: eight in the cervical region, twelve in the thoracic, five in the lumbar, five sacral and one coccygeal in the pelvic region. The first cervical issues from the spinal canal, between the occiput and the atlas vertebra, and each succeeding nerve issues between two contiguous vertebræ, the last of the series escaping between the last sacral and the first coccygeal vertebra. Each spinal nerve is composed of filaments from two separate roots, an anterior, which is the *motor root,* and a posterior, which is the *sensory root.* Both roots pierce the dura mater by separate openings (page 192), and unite within the corresponding intervertebral foramen, forming a single compound nerve. All the posterior roots, with the exception of the first cervical, are *larger* than the anterior, and are peculiarly distinguishable for the *oval ganglia* through which their fibres pass. The ganglia are for the most part situated within the interver-

tebral foramina, as shown in Plate 85, but those upon the posterior roots of the first and second cervical nerves are respectively upon the arches of the atlas and axis vertebræ (Plate 4, Fig. 2, Vol. I.), while the posterior roots of the sacral and coccygeal nerves are within the spinal canal. The compound nerves formed by the junction of the two roots as above described divide outside the intervertebral foramina into anterior and posterior divisions.

The general arrangement of the anterior divisions of the spinal nerves is as follows: the anterior divisions of the four upper cervical nerves form the *cervical plexuses* (pages 193 and 206, Vol. I.); the anterior divisions of the four lower cervical nerves and of the first dorsal nerve form the *brachial plexus* (page 344, Vol. I.); the anterior divisions of the dorsal or thoracic nerves, from the second to the eleventh inclusive, constitute the *intercostal nerves* (page 251, Vol. I.); the anterior divisions of the four upper lumbar nerves, with a connecting branch from the twelfth dorsal nerve, form the *lumbar plexus* (page 78); and the anterior divisions of the upper four sacral nerves, with the fifth lumbar and a connecting branch from the fourth lumbar nerve, form the *sacral plexus* (page 156). The distribution of the anterior divisions of the spinal nerves is described with the territories they supply, as above indicated.

The general distribution of the posterior divisions of the spinal nerves is to the erector spinæ mass and superficial muscles of the back, as well as to the skin of the back of the head, neck (page 193, Vol. I.), and trunk (page 175). The nerves of both the anterior and posterior divisions contain both *motor* and *sensory* fibres.

Owing to the respective portions of the spinal cord from which the roots of the different nerves arise not being opposite the foramina by which they leave the spinal canal, there is a great variation in the length and direction of the roots. In the upper cervical portion the roots are short and proceed transversely, the origins being nearly opposite their exits, but they become directed more and more obliquely lower down the cord, so that the roots of the different nerves originate some distance above the foramina by which they leave. In consequence of

the cord stopping at the conus in relation to the second lumbar vertebra, it follows that the roots of the lumbar and sacral nerves descend almost perpendicularly. This peculiar disposition of the roots of the spinal nerves is due to the fact that the growth of the spinal cord is not commensurate with that of the spinal column. In the early fœtus the neural canal is completely filled with the cord, but after the third month the lumbar and sacral portions of the vertebral column outgrow the cord, in consequence of the more active development of the lower extremities which takes place at that time.

There is no means of foretelling the absolute *relative positions of the origins of the individual spinal nerves* from the spinal cord, but they may be approximatively considered to be as follows. Collectively, the eight cervical nerves arise between the medulla oblongata and the cord opposite the spine of the sixth cervical vertebra. Individually, the first cervical nerve arises at the interval between the margin of the foramen magnum and the atlas vertebra, the second and third cervical nerves arise opposite the axis vertebra, while the fourth, fifth, sixth, seventh, and eighth cervical nerves arise respectively opposite the bodies of the third, fourth, fifth, sixth, and seventh cervical vertebræ. Collectively, the upper six dorsal nerves arise from the cord between the spines of the sixth cervical and fourth dorsal vertebræ. Individually, the first, second, third, and fourth dorsal nerves arise respectively opposite the intervertebral disks below the seventh cervical and the first, second, and third dorsal vertebræ, while the fifth and sixth dorsal nerves arise opposite the bodies of the fourth and fifth dorsal vertebræ. Collectively, the lower six dorsal nerves arise from the cord between the spines of the fourth and eleventh dorsal vertebræ; individually, they arise opposite the bodies of the sixth, seventh, eighth, ninth, tenth, and eleventh vertebræ. Collectively, the five lumbar nerves arise from the cord between the eleventh and twelfth dorsal spines. Individually, the first, second, and third lumbar nerves arise opposite the body of the twelfth dorsal vertebra, and the fourth lumbar nerve arises opposite the intervertebral disk between the twelfth dorsal and first lumbar vertebræ. The fifth lumbar nerve, the five sacral nerves, and the coccygeal

nerve all arise from the conus medullaris opposite the body of the first lumbar vertebra, which corresponds to the spines of the last dorsal and first lumbar vertebræ.

The levels at which the spinal nerves originate from the spinal cord as above given may be considered reliable, as they are based upon careful observation. They are of clinical value in the diagnosis of injuries and the localization of disease of the cord. Owing to the complicated relation of the nerves to the various vertebræ, the accurate interpretation of symptoms which may attend injury or disease of the cord or of the spine is very difficult. It should be remembered, in the application of the anatomy of the origins of the spinal nerves to the surface-markings, that when the patient is in the erect position the relations of the spines to the bodies of the vertebræ are as follows. The tip of the spine of the second *cervical* or axis vertebra corresponds to the position of the body of the third, the spine of the third to the body of the fourth, the spine of the fourth to the disk between the bodies of the fourth and fifth, and the spine of the fifth to the disk between the fifth and sixth (Plate 1, Vol. I.), while the spines of the sixth and seventh (prominens) are opposite their own bodies respectively. The spine of the first *dorsal* corresponds to the disk between the first and second, the spine of the second is opposite the body of the third, the spine of the third is opposite the body of the fourth, the spine of the fourth is opposite the disk between the fifth and sixth, the spines of the fifth, sixth, seventh, and eighth are opposite the bodies of the seventh, eighth, ninth, and tenth, the spine of the ninth is opposite the body of the tenth, the spine of the tenth is opposite the body of the eleventh, and the spine of the eleventh is opposite the disk between the eleventh and twelfth.

The minute anatomy of the spinal nerves.—The *fibres of each anterior nerve-root* before emerging at the anterior lateral line appear to consist of axis-cylinder processes from the large cells of the anterior cornu on the same side as the nerve, from corresponding cells of the opposite cornu, crossing in the anterior white commissure, from similar cells in the lateral cornu in the cervical and upper dorsal regions, and

from the large cells of the adjoining posterior cornu. These are augmented by fibres from the cells in the visceral column (of Clarke) (page 198). These fibres are all presumed to be under the control of the motor fibres descending from the brain in the direct and crossed pyramidal columns (of Türck) (page 201). The *fibres of each posterior nerve-root* divide after entering the posterior lateral fissure into an external and an internal series. The fibres composing the external series pass through the substantia gelatinosa and upward among the fibres of the posterior lateral column (of Burdach) (page 197). They are supposed to preside over the sensations of temperature and of the cutaneous reflexes. The fibres composing the internal series pass partly through the gray matter of the posterior cornu and partly across the gray commissure to the opposite side of the cord, and then ascend directly into the posterior median column (of Goll) (page 197). These fibres are supposed to preside over tactile sensation. Many of them are associated with the small fusiform cells in the posterior cornu and the contiguous portion of the gray commissure, and to these is attributed the conduction of the sensation of pain.

Both the anterior and the posterior divisions of the spinal nerves possess fibres which are called *trophic* because they are supposed to regulate the nourishment of the various tissues. The anterior divisions contain trophic fibres, derived from the cells in the gray matter of the anterior cornua, which regulate the nutrition of the muscles and bones. The posterior divisions contain trophic fibres which regulate the nutrition of the skin and its appendages. Associated with the trophic fibres are others, called *vaso-motor* (*constrictor* and *dilator*) *fibres,* which are distributed to the coats of the blood-vessels and regulate the vascularity of the various tissues and organs. The vaso-motor fibres probably form the chief part of the nervi communicantes, the connecting links between the two great nervous systems, the cerebro-spinal and the sympathetic. They have been especially referred to in connection with the *splanchnic nerves* (page 319, Vol. I.). Pathological and microscopic investigations seem to indicate a close relation between the trophic and vaso-motor fibres and the gray matter surrounding the central cavity through the

entire length of the cord, and they appear to be associated with the cells of the vesicular column (of Clarke).

Physiologists have established certain facts which help greatly to elucidate the complex anatomy of the spinal cord and the nerves which originate from it, among which may be here briefly mentioned the important distinction between the primary anterior and posterior roots of the spinal nerves and their ultimate anterior and posterior divisions. It has been demonstrated that the anterior nerve-roots are purely motor and that the posterior nerve-roots are purely sensory in function, whereas both the anterior and the posterior divisions are composed of fibres from both roots and are therefore both motor and sensory in function. Division or complete disorganization of the spinal cord is attended with complete loss of sensibility and motion below the point of injury, showing that the cord is the organ of communication between the brain and the external organs of sensation and of voluntary motion.

If a lesion of the medulla oblongata occurs above the crossing in the pyramids, it is followed by loss of both sensation and motion upon the opposite side. If one side of the cord is injured or disorganized, or if the white and gray matter of one-half of the cord is divided, the power of voluntary motion is lost below on the same side of the body as that of the injury, while sensation is lost on the opposite side. Attendant upon such an injury as the latter is the condition of *hyperæsthesia,* usually occurring upon the same side as the injury, and probably to be accounted for by the increase in temperature and vascularity in consequence of the division of the vaso-motor nerves. It is generally maintained that the fibres conducting motor impulses pass from the corpus striatum of one side of the brain, and, chiefly crossing at the pyramids, descend through the antero-lateral columns of the spinal cord on the opposite side to the anterior roots of the spinal nerves, and that the fibres conveying sensory impressions pass from the posterior roots of the spinal nerves across to the gray matter of the opposite side of the cord and thence upward to the corresponding optic thalamus. Moreover, experiment seems to show that fibres in the anterior and posterior columns are commissural, their function being probably the co-ordination

of muscular power, as in cases of locomotor ataxia, where voluntary motion and sensibility exist with loss of the power of muscular co-ordination. The pathological evidence afforded by such cases appears to confirm this.

There are also certain actions, termed *reflex,* which can be accounted for only upon the supposition that the spinal cord possesses in itself the power of receiving and conveying impressions independently of its connection with the brain. Thus, during sleep, when the brain is not exercising a controlling influence, if a sensory impulse is conveyed through a spinal nerve it probably passes by the posterior root into the gray matter of the cord, and then the impulse is converted into a motor one, which is *reflected* by the anterior root of the spinal nerve, causing certain muscles to contract upon the same side, or, if the impression is sufficiently strong, by the anterior roots of the spinal nerves upon both sides affecting corresponding muscles. When the brain does exercise a controlling influence, the impression received by the posterior nerve-root probably crosses to the opposite side of the cord at once and then ascends to some part of the cerebral cortex, whence a voluntary motor impulse descends to the anterior nerve-roots, which convey it to the muscles.

For the purpose of applying the anatomy of the spinal cord to the study of **spinal localization in relation to sensory, motor, reflex, vaso-motor, and trophic phenomena,** the cord itself may be regarded as composed of a series of superposed segments corresponding in a measure to the segments of the vertebral column, each segment consisting of the portion of the cord with which the several pairs of the spinal nerves are connected. Microscopic investigations have shown that the groups of multipolar cells in the cornua of the gray matter, as exhibited in cross-sections of the cord, are variously arranged in the different segments of the cord from above downward, and experiments have determined that these groups of cells are related to certain groups of muscles. The situation and comparative size of the groups of cells appear to be correlative to the origins of those nerves which are distributed to the greatest number of muscles. It has been observed that

PLATE 79.

Dissection of the female perineum, showing the muscles at the outlet of the pelvis and the superficial branches of the pudic artery. The fasciæ are carefully removed from the buttocks and hips to display the distribution of the branches of the pudic nerves.

1. The mons Veneris.
2. The clitoris.
3. The meatus urinarius.
4. The right labium majus.
5. The opening into the vagina.
6. The perineal fascia reflected.
7. The fourchette.
8. The right ischio-cavernosus muscle.
9. The central tendon of the perineum.
10. The external perineal nerve.
11. The sphincter ani muscle.
12. The right internal pudic vessels and nerve.
13. The right great sacro-sciatic ligament.
14. The right gluteus maximus muscle.
15. The coccyx.
16. The left gracilis muscle.
17. The left labium minus.
18. The left adductor magnus muscle.
19. The superficial perineal artery.
20. The sphincter vaginæ muscle.
21. The transversus perinei muscle.
22. The cutaneous femoral branch of the pudic nerve.
23. The superficial perineal nerve.
24. The left internal pudic vessels and nerve.
25. The anus.
26. The nerve to the margin of the anus.
27. The levator ani et vaginæ muscle.
28. The left gluteus maximus muscle.
29. The ano-coccygeal ligament.
30. The left fourth sacral nerve.

N.B.—This and the succeeding Plate 80 were taken from the body of a woman, aged about thirty-two years, who died in an epileptic fit. The muscles were remarkably firm, well developed, and unusually favorable for dissection, as has invariably been observed by the author to be the condition after death from convulsive diseases.

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the nuclei of the extensor muscles are situated in the outer and posterior groups of cells, while the nuclei of the flexor muscles are in the internal groups of cells; and from the predominance of one or other of these classes of muscles in paralysis may perhaps be deduced the location and extent of a lesion of the cord.

Certain cells in the gray matter of the cord are believed to constitute the **centres for reflex actions,** which are characterized as cutaneous and musculo-tendinous. The *cutaneous reflex centres* are (according to Gowers) the *plantar reflex,* which corresponds to the level of the second sacral vertebra, the *gluteal,* to the fourth lumbar vertebra, the *cremasteric,* to the second lumbar vertebra, the *abdominal* or *epigastric,* from the sixth to the eleventh dorsal vertebra, and the *scapular,* from the fifth cervical to the first dorsal vertebra. The *musculo-tendinous reflex centres* are the *foot-clonus* and the *ankle-clonus,* which are referred to the cord between the fifth lumbar and first sacral vertebræ, the *knee-jerk,* between the third and fourth lumbar vertebræ, and the *flexors* and *extensors of the upper extremity,* between the sixth and seventh cervical vertebræ. Besides these there are various complex reflex centres which are valuable for purposes of localization. Among them are the cilio-spinal, the sexual, and the vesical and rectal. The *cilio-spinal centre* is referred to the cord between the sixth cervical and second dorsal vertebræ; the *sexual centre* is probably about the second lumbar vertebra; and the *vesical and rectal centre* is in the terminal portion of the cord where the third, fourth, and fifth sacral and coccygeal nerve-roots originate.

Spinal localization is naturally fraught with great difficulty, and, like cerebral localization (page 36, Vol. I.), requires a most exact knowledge of anatomy. Much has been determined, much is inferred, but there is also much to be ascertained. It has been well said by one of the ablest of modern investigators (Mills) that the value of a study in spinal localization depends upon the exactness with which phenomena are differentiated. Nowadays there is little that the surgeon does not dare to attempt, and the cases of tumors and lesions of the cord or its membranes which present themselves for diagnosis demand that certain prac-

tical points shall be carefully considered. Among these are the lessons afforded by the lesions occurring in certain localities of the cord,—*i.e.*, the *vital centres*, which are evidently situated between the medulla oblongata and the portion of the cord in relation to the fourth cervical vertebra, any disturbance of which is followed by cardiac and respiratory phenomena.

The phenomena which have to be considered in all cases of localization are due to the abolition or perversion of sensation and motion. The sensory symptoms are pain, hyperæsthesia, anæsthesia, and paræsthesia; the motor symptoms are paralysis, spasm, contracture, and tremor.

The construction of the various segments of the vertebral column, and the arrangement of the membranes within the spinal canal, insure the safety of the spinal cord from ordinary violence, for the vertebral bodies and disks are well adapted to resist the effects of compression, while the arches, surrounded by numerous ligaments and tendons, resist the effects of laceration. The cord is so well protected that it can be readily reached only by *punctured wounds* immediately above or immediately below the atlas vertebra, unless the wound is associated with a fracture. Owing to the very loose suspension of the cord within the vertebral canal, and to the protection afforded by the arrangement of its investing membranes, as well as to the disposition of the cerebrospinal fluid, there is little possibility of simple *concussion of the cord* occurring from transmitted shock, comparable with concussion of the brain from a similar cause. The phenomena attributed to molecular disturbance in the substance of the cord are more probably due to pressure from hemorrhage into its meninges or into its own substance.

Dislocations and fractures of the spinal column are especially grave because of the damage to the spinal cord which usually attends them. A simple dislocation of any of the vertebræ can happen only in the cervical region, as the construction of the dorsal and lumber vertebræ is such that a dislocation necessarily involves a fracture of some part of the bone. Even in the neck a dislocation is extremely rare, and when it occurs it is usually at the fifth cervical vertebra,—which can be accounted for by the degree of movement of this portion of the column,

the comparatively small size of the vertebral bodies, and the obliquity of their articular processes. The usual deformity depends upon the displacement of the body of the vertebra affected downward and forward upon the body of the vertebra below, thus encroaching upon the vertebral canal and endangering the cord from pressure. The degree of displacement without any symptoms of pressure is often very considerable, owing to the absence of attachment of the spinal dura mater to the walls of the canal, and to the relatively small size of the cord. *Fractures* are produced chiefly by indirect violence, as in forcible bending of the spinal column forward, which crushes the bodies of the vertebræ together. In such cases there is always more or less laceration of the intervertebral fibro-cartilages and of the ligaments, with fracture of the vertebral arches, consequent upon the sliding forward of the vertebral bodies. Fractures due to direct violence usually involve only the vertebral arches, the bodies escaping unhurt. In this form of injury there is rarely much displacement, and therefore severe injury to the cord or its membranes is less apt to follow than in lesions caused by indirect violence. It is only when the arches of the vertebræ are involved in the direct form of fracture that the operation of trephining or resection of the spinal column can be considered justifiable, as in those cases where the bodies are overlapped by indirect force the displacement cannot be remedied by operation.

In the different forms of *caries* which affect the bodies of the vertebræ, although the spinal cord usually accommodates itself to the progressive pressure, there are certain characteristic symptoms due to the pressure upon the spinal nerves. The *peripheral pains* thus produced can be interpreted by a knowledge of the areas of the distribution of the several spinal nerves, as has already been explained with regard to the cutaneous nerves of the abdomen (page 8). When any of the upper three vertebræ in the cervical region are diseased, pain is often complained of in the areas supplied by the occipital and great auricular nerves (Plate 53, Vol. I.). If the fourth and fifth cervical vertebræ are diseased, pain may be referred to the distribution of the sternal, clavicular, and acromial nerves (Plate 19, Vol. I.). If the sixth

and seventh cervical vertebræ and the first dorsal vertebra are diseased, pain may be referred to the shoulder and down the arm in the course of the branches of the brachial plexus of nerves (Plate 27, Vol. I.). When any of the upper six vertebræ in the dorsal or thoracic region are diseased, pain is felt in the course of the corresponding intercostal nerves; and if any of the lower six vertebræ are affected, pain may be referred to the epigastric, umbilical, or hypogastric region, in the areas supplied by the seventh, eighth, ninth, tenth, and eleventh intercostal nerves, and in the course of the subcostal nerve, which supplies the skin of the flank below the crest of the ilium (Plate 97). In the lumbar region the nerves liable to pressure are the branches of the lumbar plexus, notably the ilio-hypogastric, ilio-inguinal, genito-crural, and anterior crural nerves, and pain is sometimes referred to the course of the internal saphenous nerve as far as the ball of the great toe (Plate 90), which can be attributed to spinal origin rather than to the gout. The pains experienced in spinal disease are always accompanied by a peculiar constricting sensation, as if a tight band were clasped about the body in the site of the affected nerves, and hence they are often denominated girdle-pains. They are generally symmetrical.

Caries of the spine usually results in the formation of abscesses, which, in the different localities, pursue certain directions in consequence of the special arrangement of the neighboring fasciæ. *Cervical caries* results in post-pharyngeal abscess, which if not promptly evacuated may extend outward between the layers of the deep cervical fascia which form the stylo-maxillary ligament (page 133, Vol. I.), or may pass downward behind the œsophagus into the posterior mediastinum. In *dorsal* or *lumbar caries* the pus generally descends upon the back wall of the abdomen and collects as a psoas or lumbar abscess, being directed to the groin by the ilio-psoas fascia to the outer side of the femoral vessels (page 69). Such an abscess may even descend into the pelvis and pass thence into the ischio-rectal fossa or through the great sacro-sciatic foramen, or, as the quadratus lumborum muscle is a thin, weak plane of muscle-fibres, it may issue through it into the region of the loins and become a lumbar abscess.

THE LUMBAR REGION, OR THE LOINS.

Much of the anatomy belonging to the loins has necessarily been described with the abdomen and the back, and therefore a detailed account of all the structures found here will not be repeated. The lumbar region may be considered as limited by the twelfth ribs above and the crests of the ilia below (Plate 83, Fig. 1). The muscles which fill in this interval, and thereby contribute to the formation of the lateral and posterior walls of the abdomen, are the latissimus dorsi (page 175), the external and internal oblique (page 9), the transversalis (page 13), the erector spinæ mass (page 178), and the quadratus lumborum (page 70). The latissimus dorsi overlaps the external oblique above, but below these muscles are separated by a small triangular space, the *triangle of Petit* (Plate 83, Fig. 2, No. 13). This space is immediately above the middle of the posterior portion of the crest of the ilium, nine centimetres, or about the breadth of the hand, from the lumbar spines, and corresponds to the outer border of the quadratus muscle, which, however, slopes upward and backward (Plate 84, Fig. 1, Nos. 9 and 19). The upper and inner portions of the quadratus muscle are completely covered by the erector spinæ mass and the dense *lumbar fascia* (page 177), which at its outer border receives the attachment of the fasciæ investing the external and internal oblique and transversalis muscles, forming the *lateral intermuscular septum.* At this septum the fascia of the transversalis separates into three layers, the outer layer being continued with the expansions of the fasciæ of the internal oblique and external oblique over the erector spinæ mass to the spines of the lumbar vertebræ, thus constituting the deep layer of the lumbar fascia, the middle layer passing between the erector spinæ and the quadratus lumborum to the tips of the transverse processes of the vertebræ, and the inner layer passing over the abdominal surface of the quadratus lumborum muscle to be inserted at the front part of the transverse processes. This is the weakest of the three layers, and extends upward to the lower border of the twelfth rib, where it forms

the ligamentum arcuatum externum (page 321, Vol. I.). The quadratus and erector spinæ muscles are thus enclosed by definite sheaths, which, in cases of abscess occurring in the loose fatty tissue behind the kidneys (Plate 84, Fig. 1) or in the lumbar vertebræ (page 214), may serve to limit the suppuration; but, as both the quadratus muscle and its sheath are very thin and yielding, they offer little resistance to protrusions from within. Occasionally a portion of the bowel escapes at this locality, constituting a *lumbar hernia,* and appears on the surface as a slight bulging tumor over the triangle of Petit, which is generally larger in the female than in the male, as previously stated (page 177). It should be noticed that the twelfth intercostal artery and nerve pierce the lumbar fascia near the twelfth rib, and that the ilio-hypogastric nerve and its accompanying artery pierce it near the crest of the ilium.

When the posterior expansions of the abdominal muscles and their fasciæ, together with the lumbar fascia and the extra-peritoneal fascia, which in this region forms a very delicate sheath over the abdominal surface of the quadratus lumborum muscle, are removed, the back wall of the abdominal cavity is opened. There is always a considerable quantity of fatty areolar tissue (Plate 84, Fig. 1), which more or less conceals the kidneys and the adjacent portions of the colon. If this is removed carefully, the relative positions of these organs upon both sides will be exposed (Plate 84, Fig. 2). Upon the *left* side, the lower border of the spleen, covered with the peritoneum, is seen appearing below the eleventh rib and impinging upon the upper portion of the left kidney, the posterior surface of which is crossed by the twelfth rib and the subcostal, ilio-hypogastric, and ilio-inguinal nerves. Below the kidney and a little to the outer side is the descending portion of the colon, which in this situation is usually more fixed than is the ascending portion upon the opposite side, and is uncovered by peritoneum, varying from two and a half to five centimetres, or from one to two inches, according as the bowel is empty or distended. The left renal vessels enter the hilum of the kidney about opposite the disk between the first and second lumbar vertebræ, and the ureter and spermatic vessels descend in close relation to the outer border of the corresponding psoas muscle.

e operation of *colotomy* is preferably done upon the *left* side of
nbar region, because the descending portion of the colon is nearer
us, has a greater extent of non-peritoneal surface than the bowel
he opposite side, and is more accessible on account of the higher
n of the left kidney (Plate 84, Fig. 1). An incision is made
ly across the loin similar to that above described for nephrotomy,
ro centimetres, or about three-quarters of an inch, nearer the
The descending colon will probably be found in relation to the
between the psoas and quadratus lumborum muscles. It should,
ticable, be previously distended, as not only will the bowel be
nore clearly recognizable,—the sacculi and the appendices epi-
(page 44) distinguishing it from a loop of the small intestine,
its non-peritoneal surface will also be presented directly before
erator. When the bowel is empty there is very little difference
i its diameter and that of the jejunum. The simple procedure
ing the body of the patient to the left side will often dispel
ubt by causing the sought-for portion of the colon to protrude
incision; but in these days, when the surgeon has so much less
of injuring the peritoneum than formerly, he surely need not be
ed with a small opening into the abdominal parietes. When the
bowel is reached it is drawn forward and stitched to the margins of the wound, and opened by transverse incision, so as to establish an artificial anus.

Colectomy, or resection of a portion of the colon, is usually performed through the same incision as colotomy.

THE LOWER EXTREMITY.

The Gluteal Region.—The buttocks, or *nates*, are separated from each other by a deep median groove which extends from the hollow or small of the back to the perineum. The prominences on each side of this groove are peculiar to man, and consequent upon the erect position which he naturally assumes. Each buttock is limited by the crest of the ilium above and the fold which forms a marked curve below, across the back of the upper part of the thigh. The *landmarks* can be readily made out (Plate 83, Fig. 1). The crest of the ilium and its anterior spine are superficial. The posterior spine of the ilium can be felt by following the crest backward to its termination. It is on a level with the spinous process of the second sacral vertebra and behind the corresponding sacro-iliac joint, and is marked by a dimple on the surface. The great trochanter of the femur is usually conspicuous, dependent upon the development of the muscles which fill up the interval between the trochanter and the ilium. If there is much fat in the subcutaneous tissue, the position of the trochanter is indicated by a depression. The tuberosity of the ischium can be felt through the soft structures, especially when the hip is flexed, as in the sitting position. The surface-markings in connection with the landmarks are frequently referred to in diagnosing affections of the hip-joint. The *gluteal fold* (sulcus of the nates) becomes obliterated in diseases of the hip-joint, in consequence of the habitual flexion of the hip. *Nélaton's line* is drawn across the flank from the anterior superior spine of the ilium to the tuber ischii, and passes across the middle of the acetabulum over the top of the great trochanter.

The *skin* over the buttock is thick, coarse, and peculiar for its low vascularity, on account of which it is frequently the seat of boils. The *subcutaneous fascia* is loose, and contains much fat in its meshes. It is united to the skin by many strong fibrous bands, especially along the gluteal fold, and over the tuberosity of the ischium, where it is remarkably tough (page 160). The roundness and prominence of the buttock

are due chiefly to the amount of fat in the superficial tissue, which is usually more developed in females than in males, and is a characteristic feature in some African tribes. This tissue is very liable to become the seat of lipomata, and its laxity favors the collection of blood or pus, so that a gluteal abscess sometimes attains an enormous size. An early symptom of disease of the hip is flattening of the buttock over the affected joint, produced by the wasting of the fatty tissue. The *deep fascia* is a dense membrane attached to the crest of the ilium, the lumbar fascia, and the back of the sacrum and coccyx. It is thick and white anteriorly where it covers the gluteus medius muscle, below which it splits into two layers which pass over and beneath the gluteus maximus muscle, completely enveloping it. The superficial layer passes round the lower border of the muscle, and is attached to the borders of the greater sciatic ligament between the tuberosity of the ischium and the coccyx, whence it is continuous with the fascia lata of the thigh. Externally it blends with the tendon of the gluteus maximus. From its under surface fibrous septa pass into the substance of the muscle, ensheathing its fascicles. The deep layer, beneath the gluteus maximus, encloses the gluteus medius and gluteus minimus muscles, so that they are bound down within an osseo-aponeurotic space. Extravasations of blood or matter beneath this fascia are often pent up and directed down the thigh by its attachment to the ilio-tibial band (page 245).

There are many *cutaneous branches of nerves* which appear passing through the deep fascia. Near the crest of the ilium, *the external branches of the posterior division of the first and second lumbar nerves* descend obliquely forward (Plate 83, Fig. 2, No. 11). The *posterior cutaneous branches of the sacral nerve* appear at the sacral border of the gluteus maximus, and the *gluteal branch* of the external cutaneous curves backward over the tendinous expansion of the muscle. The *recurrent cutaneous branch of the lesser sciatic nerve* (Plate 89, Fig. 1, No. 2) turns upward round the border of the gluteus maximus, between the great trochanter and the tuberosity of the ischium. The *perforating* cutaneous branches of the fourth sacral nerve emerge through the muscle near the sciatic ligament.

The *gluteus maximus muscle* is the largest muscle in the body, and its development is characteristic of man. It is very thick, and composed of coarse bundles of fibres intimately connected with the investing sheath of the deep fascia. It arises by short tendinous fibres from the posterior gluteal line of the ilium and the rough surface of the bone behind it, from the lumbar fascia and the spines of the sacrum and coccyx, and from the inner portion of the great sciatic ligament. Its fibres pass obliquely to be inserted into the fascia lata on the outer part of the thigh, crossing over the great trochanter, blending with the sheath of the vastus externus muscle, and into the rough gluteal ridge upon the femur between the linea aspera and the great trochanter. Its lower margin forms the gluteal fold. This muscle is supplied by the lesser sciatic nerve and branches from the sacral plexus of nerves, and with blood by the superficial branches of the gluteal and sciatic arteries. The action of the gluteus maximus abducts the thigh and rotates it outward, making tense the fascia lata. It extends the thigh-bone upon the pelvis, and thus serves to raise the body from the sitting to the erect position. In walking it acts from the thigh to the pelvis, maintaining the body upright. It also aids in propelling the body in running and leaping. There is a large bursa between the insertion of the gluteus maximus and the great trochanter, which sometimes becomes inflamed and gives rise to great pain in movement of the limb. The muscle should be detached and reflected to expose the parts beneath it (Plate 89, Fig. 2). In doing so the vessels and nerves will be noticed entering its deep surface.

The *gluteus medius muscle* is a triangular fleshy mass arising from the area of bone between the crest of the ilium and the superior curved line. Its fibres converge to a flat tendon which is attached to an oblique line on the upper and outer surface of the great trochanter, having a small bursa interposed between it and the bone. It receives the ascending branch of the deep gluteal artery, and a branch from the superior gluteal nerve. Its action from the ilium is to abduct the thigh and to rotate it inward, while acting from the femoral insertion it extends the pelvis outward, thereby assisting in balancing it when standing on one leg.

The *gluteus minimus muscle* is separated from the medius in its upper part by a large branch of the gluteal artery, but at its inferior border in front it is intimately connected with the medius, as they are both attached there to a tendinous band extending from the ilium to the trochanter, the *ilio-trochanteric band,* which blends with the capsule of the subjacent hip-joint. The gluteus minimus arises from the area of the ilium as far back as the border of the greater sciatic notch. Its tendon is attached on the front and outer part of the great trochanter. This muscle is also supplied by the superior gluteal nerve, which enters the outer surface. Its main action assists the other glutei muscles in balancing the pelvis. Acting from the ilium it serves to abduct the thigh, while in conjunction with the anterior portion of the gluteus medius it assists in rotating the thigh inward.

The gluteal artery is the largest branch of the internal iliac artery (Plate 76, Fig. 1, No. 19). It makes its exit from the pelvis above the pyriformis muscle through the great sciatic notch, and runs over the ilium, with its vein above and the nerve beneath it, between the gluteus maximus and gluteus medius muscles (Plate 89, Fig. 2, Nos. 3 and 34). The artery gives off the *external nutrient artery* to the ilium, and divides into *superficial* and *deep* branches. The *superficial gluteal artery* passes between the gluteus maximus and gluteus medius, supplying both of them, its twigs establishing anastomoses with the posterior sacral and sciatic arteries. The *deep gluteal artery* passes between the gluteus medius and gluteus minimus and supplies them and the pyriformis muscle. Its branches communicate beneath the superior iliac spine with the ascending branches of the external circumflex and circumflex iliac arteries, and by an inferior branch with the external circumflex and sciatic arteries. The latter branch supplies a twig to the hip-joint and to the tensor vaginæ fasciæ femoris muscle. The companion veins to all these arteries have many valves. They unite into the *common gluteal vein* as they converge toward the sciatic notch. The gluteal artery is not uncommonly affected with aneurism, and its branches are often wounded. Its position upon the surface may be indicated by drawing a line from the posterior superior spine of the ilium to the

great trochanter when the thigh is rotated inward. The junction of the inner and middle thirds of this line corresponds to the point of exit of the artery from the great sciatic notch. The superior gluteal nerve which accompanies the gluteal artery is a branch from the lumbo-sacral cord (page 156), being composed of fibres from the anterior branches of the posterior divisions of the fourth and fifth lumbar and first sacral nerves. It is beneath the artery as it issues from the pelvis, and its branches then appear in front of those of the artery (Plate 89, Fig. 2).

The *pyriformis muscle* appears below the gluteus medius (Plate 89, Fig. 2, No. 37). It arises within the pelvis by fleshy digitations from between the second, third, and fourth anterior sacral foramina, and its fibres converge, and, passing out of the great sciatic notch, receive fibres from the margin of the notch and the great sciatic ligament. Its tendon is inserted into the upper border of the great trochanter, behind the insertion of the obturator internus muscle. Within the pelvis it serves as a muscular bed for the sacral plexus of nerves, from the second cord of which it receives its nerve-supply, and it divides the great sciatic notch into two parts. The gluteal vessels and nerves emerge above it, and the sciatic and pudic vessels emerge below it. It should be noted that occasionally the great sciatic nerve or its peroneal portion pierces the substance of the pyriformis muscle. The author has met with this condition seven times in his own dissections. The arteries which nourish the pyriformis are derived from both the gluteal and the sciatic. The action of the muscle is to abduct and rotate outward the thigh, or if the femur is the fixed point it assists in steadying the pelvis.

The *obturator internus muscle* arises within the pelvis from the inner surface of the ischio-pubic rami, from the obturator membrane and the inner half of the obturator fascia, and from the ilium below the ilio-pectineal line as far as the upper margin of the great sciatic notch. Its fibres converge to a tendon which passes round the surface of the tuberosity of the ischium at the lesser sciatic notch, which is here provided with cartilage and serves as a trochlea, or pulley, over which the tendon plays as it emerges from the lesser sciatic foramen, and, overlapped by the gemelli muscles, is inserted into the top of the great trochanter,

below the tendon of the pyriformis, with which it is often united. If the muscle is reflected, it will be seen that the fibres from their several origins pass into four tendinous bands, which combine just before the insertion. A layer of fat intervenes between the muscle and the posterior portion of the obturator membrane. Its pelvic surface is covered with the obturator fascia, which is derived from the pelvic fascia, as described on page 127, and is attached below to the margin of the great sciatic ligament. The intra-pelvic and extra-pelvic portions of the muscle form with each other an angle of seventy degrees. The muscle is reinforced by the two gemelli muscles,—the *superior gemellus,* arising from the upper and outer margin of the lesser sciatic notch and from the base of the ischial spine, and the *inferior gemellus,* arising from the tuberosity of the ischium. The tendons of the gemelli blend with the tendon of the obturator internus upon its under surface and its upper and lower margins, and they are all inserted together into the top of the trochanter. Owing to this common tendon and their combined action, they are now sometimes considered under the name of the *triceps rotator femoris.* The three muscles generally receive their nerves from branches of the sacral plexus: occasionally, however, the pyriformis will be found to be supplied by the pudic nerve. Although the chief action of these muscles is to rotate the thigh outward, it should be observed that in the sitting position they become abductors of the thigh. There are always one or more little bursæ beneath the tendon of the obturator internus, interposed between it and the ischium, which serve to diminish friction, and there is very generally a bursa between the common tendon and the capsule of the hip-joint. Sometimes these bursæ intercommunicate.

The *quadratus femoris muscle* (Plate 89, Fig. 2, No. 38) arises from the outer border of the tuberosity of the ischium by short tendinous fibres, and consists of a short transverse mass which is attached to the back of the great trochanter and the vertical line (*linea quadrati*), extending as far as the insertion of the adductor magnus muscle. A terminal branch of the internal circumflex artery usually appears at the under border of the quadratus. Its nerve is from the great sciatic nerve, and it co-operates with the gemellus inferior in acting as an external

PLATE 81.

Figure 1.

The bladder drawn forward and the vagina backward, after detachment of the vesico-vaginal fascia.

1. A hook introduced into the meatus urinarius.
2. The bladder drawn forward.
3. The cut recto-vesical fascia.
4. The right middle vesical artery.
5. The right ureter.
6. The vaginal artery.
7. The right tuber ischii.
8. The right great sacro-sciatic ligament.
9. The vagina drawn backward.
10. Reflected portion of the right gluteus maximus muscle.
11. The cut recto-vesical fascia.
12. The left middle vesical artery.
13. The left ureter.
14. The left vaginal artery.
15. The left great sacro-sciatic ligament.
16. The left gluteus maximus muscle.
17. A hook fastened to the detached vagina and drawing it backward.

Figure 2.

The vagina dissected from the rectum and drawn forward, while the rectum is drawn backward to demonstrate the relative position of the peritoneum to the perineum in the female.

1. A hook introduced into the anterior part of the detached vagina.
2. A portion of the right fascia lata.
3. The vagina drawn forward.
4. The recto-vesical fascia.
5. The vaginal artery.
6. The recto-uterine fold of the peritoneum.
7. The middle hæmorrhoidal artery.
8. The coccygeus muscle.
9. The right great sacro-sciatic ligament.
10. The rectum drawn outward and backward.
11. Reflected portion of the right gluteus maximus muscle.
12. The left adductor magnus muscle.
13. The recto-vesical fascia.
14. The left semi-tendinosus muscle.
15. The tuberosity of the left ischium.
16. The left tuber ischii.
17. The left great sacro-sciatic ligament.
18. The anus.

rotator of the thigh. The quadratus muscle is covered by the gluteus maximus muscle, and the sciatic vessels and nerves descend over it.

The sciatic artery is smaller than the gluteal artery. It also arises from the internal iliac, and leaves the pelvis between the pyriformis and coccygeus muscles, and in the gluteal region appears issuing between the pyriformis and the superior gemellus (Plate 89, Fig. 2, No. 37), above the great sciatic nerve. Within the pelvis the branches of the sciatic are distributed to the rectum, the bladder, the prostate gland, and the seminal vesicle; outside of the pelvis the branches are a *coccygeal artery,* which supplies the tissues over the coccyx, an *inferior gluteal artery* to the gluteus maximus muscle, *muscular arteries* to the pyriformis and gemelli muscles, the *anastomotic artery,* which is quite large and passes over the quadratus muscle to join the branches from the internal circumflex, the first perforating artery, and the transverse branch of the external circumflex (all from the femoral artery), thus establishing the *crucial anastomosis.* The last branches of the sciatic artery are a small *articular,* which pierces the capsule of the hip-joint, entering it from the digital fossa, and the *arteria comes nervi ischiatici,* which accompanies the great sciatic nerve and enters its substance about the middle of the thigh. This artery is usually very small, although occasionally conspicuous (Plate 89, Fig. 2, No. 7) and capable of being traced as far as the beginning of the popliteal space. It is well to note that this artery forms an important part of the collateral circulation after ligation of the femoral artery (page 259).

The *venæ comites* of the sciatic artery are large and often varicose. They unite to form the *sciatic vein,* which is at the inner side of the artery.

The great sciatic nerve is formed of about thirty-eight bundles of fibres from the union of the last lumbar and upper four sacral nerves (page 156) upon the pelvic surface of the pyriformis muscle, behind the pelvic fascia (page 224). It is the largest nerve in the body, being sixteen millimetres, or about three-fourths of an inch, in breadth, and six millimetres, or about one-fourth of an inch, in thickness. The nerve-cord can be separated into two parts, which constitute

the *peroneal* and *popliteal portions.* The fibres which form the peroneal portion are derived from the posterior divisions of the anterior branches of the sacral plexus, the popliteal portion being formed of the fibres from the anterior divisions of the anterior branches of the plexus. The combined nerve-cord issues from the pelvis usually below the pyriformis muscle, although, as previously stated, it sometimes pierces that muscle (page 224). It descends over the external rotator muscles between the tuberosity of the ischium and the great trochanter, and thus escapes the effect of ordinary pressure. Its exact relations should be carefully observed, as it is frequently affected with neuralgia. Its position (Plate 85, No. 47, and Plate 89, Fig. 2, No. 4) is near enough to the surface to render it liable to suffer from cold and dampness, which are frequently the causes of many of the forms of *sciatica.* The proximity of the hip-joint should be remembered, as the nerve is liable to be affected by sudden and violent movements of the hip. In one case of old dislocation of the hip the author found the nerve actually stretched over the anterior surface of the neck of the femur, so that evidently it had been the cause of failure in the attempt at reduction of the bone to its place. As the sciatic nerve leaves the sciatic notch it sends a *branch to the obturator internus muscle,* which passes in through the lesser sciatic notch and divides into several branches upon the pelvic surface of the muscle. There are one or two branches from the sciatic nerve to the hip-joint which pierce the back of the capsular ligament. The further description of the nerve will be found with that of the other structures on the back of the thigh (page 265). If the greater sciatic ligament be divided, and the parts cleaned of the loose fatty tissue in the lesser sciatic notch, the relations of the pudic artery and pudic nerve to the spine of the ischium will be seen. The *pudic artery* is accompanied by two large pudic veins. The *pudic nerve* passes out of the greater sciatic notch internally to the great sciatic nerve, beneath the sciatic artery. It winds round the spine of the ischium and enters the lesser sciatic notch with the pudic artery. Thence they both pass in a canal formed of the obturator fascia. Their distribution is described with the perineum (page 167).

THE REGION OF THE HIP.

The Hip-Joint.—The adaptation of the head of the femur to the acetabulum constitutes a much more perfect *enarthrodia,* or ball-and-socket joint, than that formed at the shoulder by the head of the humerus and the glenoid cavity of the scapula (page 332, Vol. I.).

The upper end of the femur, or thigh-bone, consists of a head, a neck, and two rough processes called the greater and lesser trochanters. The *head* is the globular portion which in the erect position is directed upward, inward, and a little forward to be received into the acetabulum, the large cup-shaped cavity of the innominate bone (page 102). The head forms about three-fifths of a sphere, is smooth, and in the recent state is covered with cartilage, except at a small ovoid depression, the *fovea capitis,* a little behind and below the axis of the head, where the ligamentum teres is attached. The *neck* is the portion of the bone which connects the head with the shaft. It is cylindrical, slightly compressed from before backward, and somewhat constricted toward the middle. It is shorter above and longer below, where it is widely expanded, extending between the trochanters. The neck varies in length and obliquity. In the adult male it forms an angle of about one hundred and twenty-five degrees with the shaft; in the adult female, owing to the greater width of the pelvis, the angle is somewhat less, about one hundred and eighteen degrees. In infancy the neck is comparatively small, and the angle is about one hundred and sixty degrees. There is almost every variety of angle, and, although there does not generally seem to be any appreciable change in the direction of the neck in consequence of old age, there are many exceptions (page 237). The anterior surface of the neck presents numerous foramina for the transmission of veins, and the posterior surface is smooth and more concave than the anterior. The *greater trochanter* is the irregular quadrilateral projection upward and outward from the shaft, having a point bent inward posteriorly so that it overhangs the *digital fossa,* into which the tendon of the obturator externus muscle is inserted. Upon the upper and anterior part of the

greater trochanter where it joins the neck is a prominence called the *tubercle of the femur.* The *lesser trochanter* projects from the lower and posterior part of the base of the neck. It is variable in shape, but usually conical. Between the trochanters at the base of the neck there is a prominent rounded ridge, called the *posterior inter-trochanteric line,* from the middle of which there is a less distinctly marked line descending vertically to the level of the lesser trochanter. This is the *linea quadrati,* for the attachment of the *quadratus femoris muscle.* The greater trochanter receives the tendons of the external rotator muscles,—*i.e.,* the gluteus medius, the gluteus minimus, the pyriformis, the obturator internus, and the two gemelli; and the lesser trochanter the tendon of the ilio-psoas muscle (page 69). Upon the anterior surface, extending from the great trochanter obliquely downward to the inner side of the shaft, is the *anterior inter-trochanteric line,* or *linea spiralis.* This joins the *linea aspera* upon the posterior surface of the shaft.

The acetabulum (or *cotyloid cavity*) of the pelvis is bounded by an irregular rim, which is thick and strong above, and serves for the attachment of the fibro-cartilage which contracts its opening and deepens the surface for the reception of the head of the femur. The iliac portion of the rim presents a slight depression, the *iliac notch,* and at the junction of the ischiac and pubic portions there is a deep notch, the *cotyloid notch,* which is continuous with a circular depression at the bottom of the cavity. This depression is called the *fovea acetabuli,* and extends mostly upon the ischium. It is perforated by foramina, and in the recent state is filled with a mass of fat. The ligamentum teres is attached to the margins of the depression as well as to those of the notch, which is converted into a foramen by the dense band of fibrous tissues called the *transverse ligament.* Through this foramen the nutrient vessels are transmitted to the hip-joint. The acetabulum is very dense above its articular surface, so as to adapt it to the transmitted weight of the trunk, while below it is very thin. This thin portion sometimes affords a route for pus to travel into or out from the pelvis, especially before the consolidation of the three segments of bone of which the cavity is formed (page 102). The acetabulum is generally a complete

bony mass at the eighteenth year. It has been noted that the pelvic wall of the acetabulum can be felt through the rectum and vagina; and this may be of service in some cases of disease of the hip-joint where the floor of the acetabulum is suspected to be involved. The articular surfaces of the bones forming the joint are provided with cartilage, which on the head of the femur is so disposed that it is thicker at the centre than at the circumference, while in the acetabulum it is the reverse. On the head of the femur the cartilage is complete, except at the fovea, for the attachment of the round ligament, and in the acetabulum it presents a horse-shoe shape, being deficient below at the depression, for the insertion of the same ligament.

The range of motion of the hip-joint is not that of a universal joint, like the shoulder, because its ligaments are peculiarly disposed so as to restrict motion to those directions which are consistent with the support of the body in the erect position. The *capsular ligament* is a remarkably strong structure, composed chiefly of longitudinal fibres, with an interlacement of oblique and transverse fibres. It is attached about the entire bony margin of the acetabulum, except at the cotyloid notch, where it is connected with it and the contiguous border of the obturator foramen. It surrounds the neck of the femur and is attached to the anterior inter-trochanteric line and the front of the base of the greater trochanter, but posteriorly it does not extend so far down, being attached to the neck twelve millimetres, or about half an inch, above the posterior inter-trochanteric line. The capsule proper is weakest behind and strongest in front, but it is greatly augmented by fibrous expansions from the sheaths of the overlying muscles, which are commonly described as accessory ligaments, although they are really inseparable from the rest of the capsule. The strongest and most important of the fibrous bands is the *ilio-femoral ligament,* which is connected, when the parts are in the natural state, with the sheath of the gluteus minimus externally and with that of the ilio-psoas internally. It extends from the margin of the acetabulum below the anterior inferior spine of the ilium to the upper part of the anterior inter-trochanteric line, and to the base of the lesser trochanter, where there is a prominence, some-

times called the *tuberculum colli.* The outer and inner fibres of this ligament are more developed than the middle portion, so that they have received the special designation of the **Y** *ligament* (*of Bigelow*), from their arrangement presenting the appearance of the letter **Y** inverted.

The pubo-femoral ligament is composed of a condensed band of fibres from the fascia between the pectineus and obturator internus muscles upon the inner part of the capsule. It extends from the ilio-pectineal eminence to the base of the lesser trochanter. The *ischio-femoral ligament* is variably developed from the fascia between the gemellus inferior and obturator externus muscles. It extends from the ischium to the circular band of fibres of the proper capsule (sometimes called the *ligament of Bertin*), and to the neck above the digital fossa. The ilio-femoral ligament greatly increases the strength of the anterior part of the capsule, and serves as a strap to prevent the extension of the thigh beyond a certain point. It also limits rotation both inwardly and outwardly. It is rarely torn in the usual forms of dislocation at the hip, but when the head of the femur is driven backward it acts as a fixed axis round which the neck rotates, so that the head is directed toward the dorsum of the ilium.

There is a bursa interposed between the ilio-psoas muscle and the front of the capsular ligament, which sometimes communicates directly with the synovial cavity of the joint. When the capsule is opened the cotyloid ligament and ligamentum teres are exposed. The *cotyloid ligament* is a fibro-cartilaginous ring which is set upon the bony margin of the acetabulum. It is thicker at its base than at its free border, so that upon section it appears triangular or wedge-shaped. It is attached to the bone by interlacing oblique fibres, and is much thicker at the upper part of the cavity, which it serves to deepen. It is covered with synovial membrane, and embraces the head of the femur, upon which it exerts the influence of suction. That portion of the cotyloid ligament which stretches across the cotyloid notch is called the *transverse ligament.* The *ligamentum teres* cannot be seen without drawing the head of the femur out of the acetabulum. It will thus be found to be somewhat flat and triangular, and not round as its name would indicate.

Besides, it cannot be truly said to be a ligament, as it is rather a condensed band of the synovial membrane of the joint enclosing a vascular pulpy mass. It is attached by a narrow end to the fovea capitis of the femur, and by a broad bifid expansion to the margins of the fovea acetabuli and the transverse ligament, and is intimately associated with the fatty pad at this situation. This structure is relaxed by abduction and made tense by adduction, and rotates inward when the thigh is bent. Possessing as it does but little of the character of a ligament, it is ruptured in every form of dislocation. It possibly renders some slight assistance to the glutei and other muscles in steadying the pelvis in the erect position. A little twig from the obturator artery passes through it to enter the head of the femur. The round ligament is sometimes absent.

The *synovial membrane* lines the entire inner surface of the capsular ligament, and is reflected upon the cotyloid ligament, over which it dips into the acetabulum, and, forming a tubular sheath about the so-called ligamentum teres, covers the articular surface of the head of the femur. It extends to the base of the neck of the bone in front, but only as far as its middle behind.

The general function of the ligaments of the hip-joint is to economize muscular effort in balancing the trunk. In this they are considerably aided by the atmospheric pressure, which is sufficient to hold the bones together after the severance of all the ligaments and of the overlying muscles.

The muscles surrounding the joint are the ilio-psoas in front, the acetabular portion of the rectus and the gluteus minimus externally, the pyriformis, the two obturators, the two gemelli, and the quadratus behind, and the pectineus internally. The *movements of the hip* are free in all directions. The *flexors* are the ilio-psoas, the sartorius, the pectineus, the adductor longus, the adductor brevis, the gluteus minimus, and the gluteus medius. Their action is limited by the action of the semi-tendinosus, semi-membranosus, and biceps muscles when the knee is extended, and by the contact of the soft parts in front. The *extensors* are the gluteus maximus, the biceps, the semi-tendinosus, and

PLATE 82.

A topographical survey of the posterior surface of the body of a well-developed adult male, with especial reference to the clinical study of the relations of the thoracic and abdominal organs; also showing the relations of the bones to the surface of the left upper extremity, and the localization of the areas of distribution of the sensory nerves on the back of the left arm and forearm.

1. Spine of the sixth cervical vertebra.
2. Spine of the vertebra prominens.
3. Spine of the first dorsal vertebra.
4. Position of the apex of the left lung in full inspiration.
5. The left clavicle.
6. The acromion process of the left scapula.
7. The dorsum of the left scapula.
8. The shaft of the left humerus.
9. Position of the apex of the heart, and the height of the arch of the diaphragm on the left side in full inspiration.
10. Position of the œsophageal extremity of the stomach.
11. Spine of the tenth dorsal vertebra.
12. Lower border of the left lung in full inspiration.
13. Position of the spleen.
14. Tip of the left twelfth rib.
15. The upper end of the ulna.
16. The head of the radius.
17. The left kidney.
18. The left ureter.
19. The descending portion of the colon.
20. The rectum.
21. Area of distribution of the cutaneous branches of the small sciatic nerves on the left buttock.
22. Tip of the coccyx.
23. The bifid spine of the fifth cervical vertebra.
24. Position of the right lung in full inspiration.
25. Spine of the second dorsal vertebra, and position of the bifurcation of the trachea.
26. Position of the top of the arch of the aorta.
27. The cutaneous area of the external supra-clavicular nerve.
28. Spine of the fourth dorsal vertebra, and position of the lower part of the arch of the aorta.
29. The right sixth rib.
30. The right seventh rib.
31. The cutaneous area of the circumflex nerve.
32. The height of the arch of the diaphragm on the right side, and the position of the upper surface of the liver.
33. Spine of the eighth dorsal vertebra.
34. The cutaneous area of the musculo-spiral nerve on the back of the arm.
35. The cutaneous area of the lesser internal cutaneous nerve.
36. The probable position of the pyloric extremity of the stomach when distended.
37. Position of the lower border of the right lung in full inspiration.
38. The cutaneous area of the musculo-spiral nerve on the back of the forearm.
39. Tip of the right twelfth rib.
40. Spine of the first lumbar vertebra.
41. The cutaneous area of the internal cutaneous nerve.
42. The right kidney.
43. Spine of the third lumbar vertebra.
44. The ascending portion of the colon.
45. The crest of the right ilium.
46. Position of the bifurcation of the abdominal aorta.
47. The cutaneous area of the musculo-cutaneous nerve.
48. The cutaneous area of the ulnar nerve.
49. Position of the right thyroid foramen.
50. The neck of the right femur.

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Designed from nature by George Mc Clellan M.D.

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the semi-membranosus. They are restricted from acting beyond a straight line by the ilio-femoral ligament. The *abductors* are the upper portion of the gluteus maximus, the gluteus minimus, the gluteus medius, the pyriformis, and, when the thigh is flexed, the obturator internus and the two gemelli. They are restrained by the adductor muscles and by the pubo-femoral ligament. The *adductors* are the adductor longus, the adductor brevis, the adductor magnus, the pectineus, the gracilis, and the sartorius. They are limited by the ischio-femoral ligament. The *external rotators* are the ilio-psoas, the adductor longus, the adductor brevis, the adductor magnus, the pectineus, the gluteus maximus, the posterior part of the gluteus medius, the two obturators, the two gemelli, the quadratus, the pyriformis, and the sartorius. The *internal rotators* are the tensor vaginæ fasciæ femoris, the anterior portion of the gluteus medius, and the gluteus minimus. The external and internal rotators are limited respectively by the outer and inner portions of the ilio-femoral ligament. The successive action of the different muscles effects the *circumduction* of the joint.

The *arteries* which supply the hip-joint are derived from the obturator, sciatic, internal circumflex, and gluteal arteries. The *nerves* to the hip-joint are supplied by the sacral plexus, the great sciatic, the obturator, and the accessory obturator nerves.

Owing to the peculiar construction of the joint, its deep position, and the thick protective covering of the soft parts, acute inflammatory affections of the hip are extremely rare. But when inflammation does occur within the joint, for the same reasons it is liable to become destructive. As in other joints, any effusion or collection of pus will first produce a swelling in those parts where there is least resistance,—in front, in the interval between the outer and inner bands of the ilio-femoral ligament, or behind, at the lowest part of the capsule. It is important to consider certain positions of the lower extremity which are characteristic of *chronic hip-joint disease*. In consequence of effusion into the joint, the thigh becomes markedly flexed, abducted, and somewhat everted, which has been demonstrated by artificial distention of the joint to be the position naturally assumed to accommodate the joint

to the excessive amount of fluid. There is apparent lengthening of the affected limb, owing to the attempt of the patient to overcome the flexion, thus producing a tilting downward of the pelvis on the side of the limb. The effort to overcome the false position of the limb induces anterior curvature (*lordosis*) at the junction of the thoracic and lumbar portions of the spine. This condition is most apparent after the hip has become ankylosed. If disease of the joint progresses, there result a train of symptoms which, although distinctive, are very obscure as to the cause,—*i.e.*, the subsequent adduction and inversion of the limb, and its consequent shortening, which may be either apparent or real. The change from abduction and eversion to adduction and inversion is probably due to the reflex irritation produced through the obturator nerves and the opposition presented to the adductor muscles by the ilio-femoral ligament. The apparent lengthening is attributed to the tilting of the pelvis, as in the similar condition attendant upon abduction, and the real shortening is consequent upon the destruction of the head of the bone and possibly of the acetabulum.

The pain at the knee which is usually complained of in the early stages of hip-disease is probably referred along the anterior crural nerve or along the sciatic and obturator, as all these nerves supply both the hip- and the knee-joint. The *anterior crural* sends a branch to the front part of the capsule of the hip, and, below, its branches to the external and internal vasti muscles are continued to the front of the knee. The *great sciatic* furnishes a twig to the back of the hip-joint, and, below, twigs from both the internal and popliteal nerves pass to the posterior part of the knee. The *obturator* sends a branch to the inner part of the capsule of the hip, and, below, to the back and inner side of the knee.

The most common form of *fractures at the upper end of the femur* are those which result from indirect violence to the neck of the bone and are called *intra-capsular fractures of the femur.* They usually occur in old people, and involve the part of the neck where it joins the head. It is astonishing what a slight degree of violence will cause such fractures, as they are very frequently due to simply catching the foot in the

bedclothes while turning over to one side, or to the shock of a misstep. This is to be accounted for partly by the fatty degeneration of the cancellous tissue of the neck of the femur in advanced age, and partly in some cases by the change of angle between the neck and the shaft of the bone. It should be remembered that the vessels which supply the joint are likely to suffer the general effect of tissue-alteration with age, their walls undergoing degeneration, and that therefore the modifications which the neck of the thigh-bone presents when a number of specimens are compared may be ascribed to a probable deficiency in quantity as well as quality of the bony elements. Although every thigh-bone which has been taken from an aged individual does not show change of angle from the usual obliquity, yet it is certain that in some instances the neck appears to have been almost entirely absorbed, and there are many specimens in every well-stocked cabinet which indicate that the variability of the angle which the neck holds to the shaft is correlative with age. In consequence of the blood which nourishes the head of the bone being supplied by the minute vessels in the ligamentum teres and in the cancellous structure of the neck, which is within the synovial membrane and is not provided with a proper periosteum, there *is no possibility of obtaining bony union after an intra-capsular fracture of the neck of the thigh;* and this fact should be impressed upon every young practitioner of surgery, or else he will, as has too often been the case with his predecessors, experience the loss of his patient in attempting the hopeless task of mending the bone. After such an injury in the aged, as soon as the shock has been recovered from, the general health and condition should receive the sole attention, the limb being merely secured in a comfortable position. If bony union is ever accomplished in the neck of the femur after a fracture, there must have been either the condition called impaction, or the injury extended without the capsule below the base of the neck, and the patient must have been young enough for the nutrient arteries to perform their function properly.

The symptoms of a fracture of the neck of the femur are *eversion* of the lower limb, which is mostly due to the natural tendency of the

limb to roll outward and partly to the action of the muscles attached to the lesser and greater trochanters, and to the relatively more fragile condition of the back of the neck of the bone, where the fracture is usually more extensive; and *shortening* produced by the glutei, semi-membranosus, semi-tendinosus, biceps, tensor fasciæ femoris, rectus, sartorius, ilio-psoas, adductors, gracilis, and pectineus muscles. There may also be swelling in front of the joint, owing to deep-seated effusion, and there is relaxation of the fascia lata, in consequence of the greater trochanter being drawn upward.

Dislocations of the hip occur in four directions: first, backward and upward upon the dorsum of the ilium; second, backward into the sciatic notch; third, downward and forward against the obturator foramen; and fourth, forward and upward upon the pubes. The first is that which is most common, and they are all produced when the violence is received while the limb is abducted. The capsule always gives way posteriorly, on account of the greater strength of the ilio-femoral ligament anteriorly, and, the ligamentum teres being readily ruptured, the head of the bone is driven at first downward from the acetabulum and then driven by the character and direction of the violence into one or other of the different positions, aided by the action of the various muscles. The position of abduction naturally conduces to dislocation, because in it the ligaments are all more or less relaxed, and the head of the femur is somewhat outside of the acetabulum and rests upon its shallowest part. In the *dislocation upon the dorsum of the ilium* the muscles which exert the greatest influence upon determining the location of the bone in its new position, after it has been directed from the cavity of the acetabulum by the dislocating force, are the glutei, semi-tendinosus, semi-membranosus, biceps, and adductor muscles. The two obturator muscles, the two gemelli, the pyriformis, and the quadratus are more or less torn, and the ilio-psoas muscle is greatly stretched. Obviously, there is always danger of the great sciatic nerve being compressed either between the neck of the femur and the short rotator muscles, or between the head of the femur and the tuberosity of the ischium.

The usual symptoms of dislocation of the hip backward are shorten-

ing, adduction, and inversion of the limb. The shortening is due to the displacement of the head of the femur above the acetabulum, while adduction and inversion are principally produced by the tension of the ilio-femoral ligament, possibly aided by the action of the ilio-psoas muscle.

The essential points in the reduction of dislocations at the hip are to relax the ilio-femoral ligament and to restore the head of the thigh-bone by the route by which it has escaped from the acetabulum. To accomplish the first the affected thigh should be *adducted* and *flexed* forcibly across the opposite thigh, then an attempt should be made by *circumduction* outwardly, aided by direct pressure, to bring the head in relation to the torn capsule, and finally, by *extension*, to cause the head to enter the acetabulum.

The formation of the flaps in *amputation at the hip-joint* can be satisfactorily made in most cases by using the knife from without inward, in the same manner as suggested by the author for the various amputations of the upper extremity (page 349, Vol. I.). The relations of the severed structures about the hip, as shown upon the formation of the flaps by the above procedure of a long anterior and short posterior flap (Plate 95, Fig. 1), are as follows. The anterior flap contains, from without inward, sections of the tensor fasciæ femoris (No. 7), the sartorius (No. 5), the iliacus (No. 4), the psoas (No. 3), the pectineus (No. 2), and the adductor longus (No. 1). In the outer angle of the anterior flap is a section of the gluteus medius muscle (No. 10), and in the inner angle are sections of the adductor brevis (No. 15) and the obturator externus (No. 17). In the lower and inner part of the anterior flap are the cut femoral vessels (No. 14), the cut profunda vessels (No. 16), the cut anterior crural nerve (No. 6), and the superficial nerves and long saphenous vein in the margin of the flap. There are several arteries on the face of the anterior flap which require a ligature. They are mostly branches of the profunda and external circumflex, while the internal circumflex artery is close to the inner side of the acetabulum. The posterior flap is formed chiefly of the gluteus maximus (No. 22), the hamstrings (Nos. 19 and 20), and the adductor

magnus (No. 18). The short external rotator muscles are severed deeper in the posterior flap, while the great sciatic nerve (No. 21) and sciatic vessels are cut on the lower border of the flap. On the face of the posterior flap there are branches of the sciatic, perforating, and circumflex arteries.

THE REGION OF THE THIGH.

The thigh is the upper part of the lower extremity, between the hip and the knee. The *femur*, the single bone of the thigh, is the longest and the strongest bone of the entire skeleton, and presents an excellent illustration of the combined influence of gravity and muscular force, its general character and development principally determining the stature. The natural position of the femur in the erect posture is more or less oblique, depending upon the angle formed between the head and the neck, as already described (page 229), and the width of the pelvis (page 111). The degree of obliquity therefore varies in different individuals, being adapted in each to the transmission of the superincumbent weight of the body, so that in walking each limb may be alternately brought into the line of the centre of gravity. The obliquity is best appreciated if the two femora are examined in an articulated skeleton, when they will be seen to converge toward the knees, so that they respectively form an angle of ten degrees with the bones of the corresponding leg below, which are straight.

The upper end of each femur consists of a head, neck, and two trochanters, which are particularly described in connection with the hip-joint (page 229). Below the inter-trochanteric lines the *shaft of the femur* is curved with a smooth anterior convexity, which is most prominent about the junction of the upper and middle thirds of the bone, from which point the anterior surface gradually flattens as it expands into the lower end. There is a decided twist in the shaft, which causes a change in the relative bearing of the anterior surface, so that above it is directed forward and outward, while below it is directed forward and inward. The posterior surface of the shaft is not proportionately

concave, owing to the projection from it of a longitudinal roughened ridge, called the *linea aspera.* When the latter is closely examined, it will be seen in a well-marked specimen to consist of two slightly-raised borders, with an intermediate furrow. The two borders of the linea aspera diverge at about the junction of the middle and upper thirds of the shaft, and pass upward upon either side toward the bases of the lesser and greater trochanters, while at the junction of the middle and lower thirds they again diverge, the outer border being here always most distinct, and are continued downward to terminate at the back of the external and internal epicondyles respectively. The smooth triangular interval between the diverging borders of the linea aspera in relation to the epicondyles is the *popliteal surface.* The inner border is rounded and much smoother than the outer where it is crossed by the femoral artery before it becomes the popliteal (page 287). The nutrient canal of the femur is about the middle of the linea aspera, and is directed obliquely upward. The lower end of the femur presents posteriorly two ovoidal *condyles,* which are separated by a deep *intercondyloid notch,* the sides of which are roughened for the attachment of the crucial ligaments, which connect the bone with the head of the tibia. Anteriorly the condyles blend, forming a smooth *trochlear surface* for the easy play of the patella in the extension and flexion of the knee. It should be noticed that the outer portion of the trochlear surface is higher and extends farther forward than the inner. The inner condyle is longer than the outer, and appears to descend lower when the isolated bone is held in the vertical position; but when the bone is in its natural position both condyles are on the same level. It is sometimes serviceable, in the reduction of a dislocation of the hip, to remember that the direction of the internal condyle corresponds nearly to that of the head of the femur. Of the two epicondyles the inner is the more prominent, and presents the *adductor tubercle* for the attachment of the tendon of the adductor magnus muscle, while the outer is rougher, and is grooved for the tendon of the popliteus muscle, which arises here.

The great trochanter and the condyles are the only parts of the femur which are subcutaneous and serve as landmarks. The shaft, like

PLATE 83.

Figure 1.

Back view of a natural (ligamentous) skeleton of a European male, aged thirty-eight years.

1. The spinous process of the first dorsal vertebra.
2. The greater tuberosity of the left humerus.
3. The infra-spinous fossa of the left scapula.
4. The inferior angle of the left scapula.
5. The shaft of the left humerus.
6. The left ninth rib.
7. The spinous process of the twelfth vertebra.
8. The left twelfth rib.
9. The internal epicondyle of the left humerus.
10. The transverse process of the third lumbar vertebra.
11. The posterior superior spinous process of the left ilium.
12. The shaft of the left ulna.
13. The great trochanter of the left femur.
14. The left carpus.
15. The acromion process of the right scapula.
16. The greater tuberosity of the right humerus.
17. The dorsum of the right scapula.
18. The inferior angle of the right scapula.
19. The shaft of the right humerus.
20. The right ninth rib.
21. The right twelfth rib.
22. The external epicondyle of the right humerus.
23. The posterior superior spinous process of the right ilium.
24. The shaft of the right radius.
25. The shaft of the right ulna.
26. The coccyx.
27. The lesser trochanter of the right femur.

Figure 2.

Dissection of the muscles of the back. The deep fascia is removed, and the perforating arteries and internal cutaneous branches of the dorsal spinal nerves are shown in their relative positions.

1. The position of the first dorsal vertebra.
2. The internal cutaneous branch of the first dorsal spinal nerve.
3. The speculum rhomboideum.
4. The deltoid fascia.
5. The left trapezius muscle.
6. The fascia over the muscles of the scapula.
7. The latissimus dorsi muscle passing over the inferior angle of the scapula.
8. The internal cutaneous branch of the ninth dorsal spinal nerve.
9. The internal cutaneous branch of the twelfth dorsal spinal nerve.
10. The spinous process of the twelfth dorsal vertebra.
11. The internal cutaneous branch of the second lumbar spinal nerve.
12. The lumbar aponeurosis over the erector spinæ mass of muscles.
13. The triangular space of Petit.
14. The left gluteus maximus muscle.
15. The right splenius muscle.
16. The right levator anguli scapulæ muscle.
17. The posterior scapular artery.
18. The right rhomboideus minor muscle.
19. The right supra-spinatus muscle.
20. The right rhomboideus major muscle.
21. The right infra-spinatus muscle.
22. The right serratus magnus muscle.
23. The right sixth rib.
24. The right seventh rib.
25. The right eighth rib.
26. The right ninth rib.
27. The right inferior serratus posticus muscle.
28. The right eleventh rib.
29. The right twelfth rib.
30. The external abdominal oblique muscle.
31. The internal abdominal oblique muscle.
32. The lumbar aponeurosis.
33. The right gluteus maximus muscle.
34. The spinous process of the sacrum.
35. Section of the fat over the right buttock.

Plate 83

[illegible] GEORGE McCLELLAN, M.D.

that of the humerus, although completely surrounded by the soft structures which it supports, contributes to the curved form of the thigh, which is always convex in front. The *surface-marking* is chiefly due to the degree of prominence of the various muscles, the outlines of which are always softened when there is much fat in the subcutaneous tissue, thus rendering the general contour of this portion of the limb more or less rounded. If the individual is well developed, and especially when the muscles are in action, there is a prominence on the front of the thigh, caused by the rectus muscle, another on the inner side, extending as far as the middle of the patella, caused by the vastus internus, and another extending along the whole length of the outer side of the thigh, and forming a gentle curve as far as the top of the patella, caused by the vastus externus. Just above the knee there is a triangular depression between the lateral prominences, corresponding to the tendon of the rectus where it is attached to the top of the patella. Upon the outer surface, over the vastus externus, there is a longitudinal depression formed by the tense condition of the ilio-tibial band of the fascia lata, which can always be felt when the hip is extended.

The *skin* over the thigh is coarse and thick on the outer and posterior surfaces, but fine and thin on the inner and anterior. It is loosely attached to the fascia beneath, except along the groove separating the vastus externus and adjacent biceps tendon, which corresponds to the outer intermuscular septum of the fascia lata. The *superficial fascia* is disposed chiefly in two layers, containing more or less fat, varying with the condition of the body, and the superficial vessels and nerves. The superficial layer is continuous with that of the superficial fascia of the abdomen above and with that of the superficial fascia of the leg below. The deep layer is attached to Poupart's ligament and about the saphenous opening of the fascia lata, where it forms the cribriform fascia (page 95). Elsewhere the superficial fascia of the thigh is very loosely connected with the deep fascia. When the skin and outer layer of the superficial fascia are removed, the superficial vessels and nerves of this region can be traced (Plate 86 and Plate 89, Fig. 1). The *arteries* are the superficial circumflex iliac, superficial epigastric, and superficial pubic.

They are all branches of the common femoral artery, and have been described in relation to the upper part of the thigh with the anatomy of the inguinal region (page 84), as have also their corresponding veins.

Upon the inner and front part of the thigh is the *internal* or *long saphenous vein,* which commences in the venous arch on the dorsum of the foot (page 341) and ascends from the inner ankle along the inner side of the leg (Plate 90, Fig. 1, No. 7) to the inner side of the knee, whence it passes to the saphenous opening, already described (page 95). Throughout its course it receives many tributaries, some of which, especially upon the inner side of the thigh (Plate 86, No. 17), are as large as the main vein. At the saphenous opening the saphenous vein receives the superficial veins of the inguinal region (page 95) before it terminates in the femoral vein. There are valves at the junction of each of the tributaries with the saphenous vein, which are especially well marked in the thigh.

The *cutaneous nerves of the thigh* are always more numerous upon the inner than upon the outer parts (Plate 86). They are the external, middle, and internal cutaneous nerves, the crural branch of the genito-crural nerve, the inguinal branch of the ilio-inguinal nerve, and the cutaneous branches of the obturator nerve. The *external cutaneous nerve* is composed of filaments from the second and third lumbar nerves. It enters the thigh close to the anterior superior spine of the ilium, pierces the fascia lata generally two and a half centimetres, or about an inch, below Poupart's ligament, and divides into an anterior and a posterior branch. The *anterior* branch passes along the outer side of the thigh as far as the knee (Plate 86, No. 8), and the *posterior* branch is distributed to the skin over the buttock and back part of the thigh (Plate 89, Fig. 1, No. 27). The *middle cutaneous nerves* are derived from the anterior crural (page 79). They pass through the sartorius muscle and the fascia lata over it, and descend over the front of the thigh as far as the knee, sending off lateral twigs which communicate with twigs from the internal cutaneous nerve and the crural branch of the genito-crural nerve. The *intern l cutaneous nerve* is also a branch of the anterior crural. It crosses obliquely over the sheath of the

femoral vessels, and divides into an anterior and an internal branch. The anterior branch terminates about the lower third of the thigh in two branches, which respectively supply the skin upon the inner and outer sides of the knee. The internal branch becomes superficial at the posterior border of the sartorius muscle above the knee, and is distributed to the skin on the inner side of the leg. It is important to note that in the majority of cases the internal cutaneous nerve crosses the femoral artery at the apex of Scarpa's triangle, and it should therefore be looked for in the operation for tying the artery. The *crural branch of the genito-crural nerve* pierces the anterior layer of the sheath of the femoral vessels and the fascia lata below Poupart's ligament, and supplies the skin in front of the thigh. It communicates with the middle cutaneous nerve, and supplies a few twigs to the sheath of the femoral artery. The *inguinal branch of the ilio-inguinal nerve* (page 79), after issuing from the external abdominal opening, supplies the skin on the inner and upper part of the thigh. The *cutaneous branches of the obturator nerve* (page 79) are generally found upon the inner side of the thigh. It is an interesting fact that branches of the internal cutaneous and obturator nerves, before they become cutaneous, unite in a plexiform manner with branches of the internal saphenous nerve (page 260) below the adductor longus muscle.

The *deep fascia of the thigh* is called the **fascia lata.** It is a dense white membrane completely investing the muscles like a tightly-fitting sleeve, thereby maintaining them in position and augmenting their power. It is variably developed in certain localities. On the outer side it is thickest and strongest, in consequence of receiving an additional band of longitudinal fibres from the tendons of the gluteus maximus and tensor fasciæ femoris muscles. This portion is called the *ilio-tibial band* or *ligament,* because it descends from the ilium and is inserted into the outer tuberosity of the tibia. The superficial portion of this band overlies the tensor fasciæ femoris muscle, and blends with the gluteal fascia (page 221) covering the gluteus medius muscle at the outer anterior part of the iliac crest, and the deep portion is attached to the inferior iliac spine externally to the rectus and iliacus muscles and

to the great trochanter. It is an important factor in maintaining the erect position, and its great resistance can be readily appreciated if it be examined when thus stretched. In fractures of the neck of the femur, when the great trochanter is drawn upward the ilio-tibial band is naturally relaxed; and this condition may prove of value in the diagnosis of such an injury (Allis). On the inner side of the thigh the fascia lata is comparatively thin. Above it is connected with Poupart's ligament, and is separated by the formation of the saphenous opening into the iliac and pubic portions, which have been carefully described with the anatomy of femoral hernia (page 95). The fascia lata furnishes from its deep surface expansions which become the sheaths of the individual muscles, and three strong *intermuscular septa* which are attached to the linea aspera upon the posterior surface of the femur and respectively separate the extensor, flexor, and adductor groups of muscles from one another.

The *tensor fasciæ* or *vaginæ femoris muscle* arises from the anterior and outer part of the crest of the ilium and from the outer border of the anterior superior spine. It descends enclosed in a strong fascial aponeurosis to be inserted into the fascia lata ten centimetres, or about four inches, below and in front of the great trochanter. It is placed between the iliacus in front and the gluteus medius behind. It is supplied by the terminal branch of the superior gluteal nerve, which pierces its sheath about the middle of its posterior border. The function of this muscle is to make tense the fascia lata, and therefore to steady the pelvis upon the femur. It is closely connected with the gluteus medius muscle (page 222), the anterior portion of which it assists in rotating the thigh inward. When the anterior portion of the fascia lata is removed, the group of muscles which surround the anterior surface of the femur are exposed (Plate 86).

The *sartorius muscle* (Plate 86, No. 40) is a very long, flat, ribbon-like band of parallel fibres arising from the top of the anterior superior spine of the ilium and the surface of the notch below it for two centimetres, or about three-fourths of an inch. It passes obliquely across the front of the thigh to the inner side, and then descends vertically as

far as the knee, where, behind the internal condyle of the femur, it becomes tendinous, and is inserted by a flat semilunar expansion into the inner and front part of the tibia below its tubercle. The tendinous expansion covers the insertions of the tendons of the gracilis and semi-tendinosus muscles, and becomes continuous with the fascia of the leg. There is a bursa between the tendon of the sartorius and the internal lateral ligament of the knee-joint which sometimes becomes enlarged. The sartorius is supplied by a branch of the anterior crural nerve, which pierces its sheath with the middle cutaneous nerve (Plate 86, No. 11). The internal saphenous vein and nerve are close to its posterior border, behind the knee.

The action of the sartorius is very complex. It assists in flexing and abducting the hip, at the same time rotating the leg inward so that with the action of the gracilis and the semi-tendinosus the knee can be flexed (page 280). It serves to steady the pelvis on the thigh. Acting from above, it first bends the leg upon the thigh, and then the thigh upon the pelvis, and then rotates the thigh outward. Acting from the leg, it bends the pelvis upon the thigh and rotates it slightly inward. The muscle was called *sartorius* from the action of the two muscles of both limbs assisting in crossing the legs, as in the squatting position assumed by tailors when at their work. The sartorius is the longest muscle of the body, and, being subcutaneous through its entire length, produces a peculiar surface-marking in children before they have learned to stand or walk. This is indicated by a spiral crease across the middle of the thigh, and is due to the habitual tendency to cross the legs at that period of life, which may be regarded as a temporary survival of the flexed position of the lower limb and inversion of the foot of embryonic life. In the well-developed adult the sartorius, when in action, presents a slight curved elevation over its upper portion, while its lower portion produces a furrow, owing to the strap-like manner in which it compresses the adductor muscles.

At the upper part of the thigh there is a triangular space, called the *superficial femoral space,* or *Scarpa's triangle,* which is formed upon the outer side by the upper third of the sartorius muscle, upon the

inner side by the adductor longus muscle, and above by Poupart's ligament, which constitutes the base of the triangle. As this locality is of special interest in connection with the femoral vessels, it will receive special attention (page 254) after the description of the extensor muscles upon the front and the adductor muscles on the inner side of the thigh.

The extensor muscles of the thigh cover the entire shaft of the femur except the linea aspera, and consist of four fleshy masses, the *rectus*, the *vastus externus*, the *vastus internus*, and the *crureus*, so arranged that they collectively form the *quadriceps extensor femoris muscle* (Plate 86). The *rectus femoris muscle* is the most independent of the group, occupying the central position, and producing, when in action, the anterior bulge upon the surface of the thigh. The structure of this muscle is very remarkable, and is an illustration of adaptation for great power within a short range of action. It arises by two tendinous portions from the pelvis, one from the rough surface above the acetabulum, which is flat, small, and usually called the *reflected origin* of the muscle, in distinction from the portion from the anterior inferior spine of the ilium, which is round, large, and straighter. The two portions soon join at an acute angle and form a superficial aponeurosis, which extends to the lower border of the sartorius muscle, thus affording a smooth surface for that muscle to glide over. Below the sartorius the aponeurosis narrows into a median tendinous line, from which the fleshy fibres arise descending in two lateral series diverging from each other, giving a bipenniform appearance to the mass of the muscle, which is regularly fusiform, being broad in the middle and pointed at the upper and lower ends. The deep fibres descend vertically and are inserted into the expansion of the united tendon on the deep surface of the upper part of the muscle. The superficial and deep fibres at the lower end of the muscle terminate in a strong flat tendon, which receives upon its outer and inner margins the insertions of the external and internal vasti muscles respectively, and is itself inserted into the upper border and anterior surface of the patella, some of the fibres passing over the patella to join with those of the ligamentum patellæ. When the rectus is brought into decided action its tendon produces a marked depression

above the knee, called the *supra-patellar flat.* The acetabular or reflected tendon is the primary portion of the rectus muscle. The rectus is supplied by a branch of the anterior crural nerve, and its arteries are derived from the femoral and the external circumflex.

The vastus externus, the vastus internus, and the crureus are so closely associated that they are sometimes called the *triceps extensor femoris.* Their separation is very difficult, and they can be fully seen only by dividing the rectus and reflecting it. The vastus externus blends with the crureus close to the femur, while the vastus internus is inseparable from the crureus superficially and at its insertion at the patella.

The *vastus externus muscle* is the largest portion, and arises tendinously from the ridge at the anterior part of the base of the great trochanter, from the outer edge of the gluteal line, from the outer border of the linea aspera, and from the lower portion of the external intermuscular septum. Its fibres descend to be attached by a widely-expanded tendon, commencing on the under surface of the lower part of the muscle, to the outer border of the rectus and into the outer border of the patella, many of the outermost fibres being continued into the ligamentum patellæ. The vastus externus is covered above by the gluteus maximus, the tensor fasciæ femoris, and the gluteal bursa, but for the rest of its extent it is superficial, being firmly strapped down by the ilio-tibial band of the fascia lata. It is supplied by the anterior crural nerve, and receives its blood from branches of the external circumflex artery.

The *crureus muscle* arises by a series of fleshy fascicles from the front and outer surface of the femur, and is with difficulty separable from the vastus externus. Its fibres terminate mostly in a superficial tendon which blends with the tendons of the two vasti muscles at the upper border of the patella. It is also supplied by the anterior crural nerve, and with arteries from the external circumflex. A specialized portion of this muscle, called the *sub-crureus muscle,* is inserted into the synovial pouch which extends upward from the knee-joint and forms the *sub-crureal bursa.* This muscle is sometimes very large (Plate 88,

PLATE 84.

Figure 1.

[illegible]

1. The left [illegible] rib.
2. The intercostal vessels and nerve between the [illegible] and [illegible] ribs.
3. The left eleventh rib.
4. [illegible] of muscles.
5. [illegible]
6. [illegible] nerve.
7. The extra-peritoneal fat over the left kidney.
8. [illegible]
9. The left quadratus lumborum muscle.
10. The lumbar aponeurosis.
11. The crest of the left ilium.
12. The right [illegible] rib.
13. The right [illegible] rib.
14. The right [illegible] rib.
15. The right [illegible] rib.
16. The lower margin of the liver.
17. The right ilio-[illegible] nerve.
18. The extra-peritoneal fat over the right kidney.
19. The right quadratus lumborum muscle.
20. The crest of the right ilium.

Figure 2.

The [illegible] of the kidneys seen from behind after removal of the muscles and the extra-peritoneal fat.

1. The left [illegible] rib.
2. [illegible] nerve.
3. [illegible]
4. The left twelfth rib.
5. The left ilio-hypogastric nerve.
6. The left kidney.
7. The left ureter.
8. Portion of the [illegible]
9. The left [illegible]
10. Bifurcation of the [illegible] arteries.
11. The crest of the left ilium.
12. The right [illegible]
13. The right eleventh rib.
14. The right twelfth rib.
15. The supra-spinous ligament.
16. The liver.
17. The right kidney.
18. The right renal artery and vein.
19. The right ilio-inguinal nerve.
20. The right ureter.
21. Portion of the ascending colon.
22. The right spermatic artery and vein.
23. The crest of the right ilium.

Fig 1

Fig 2

Dissected Photographed and Colored from Nature by George Mc Clellan, M D

Armstrong & Co Lith Boston

Nos. 18 and 42), although it is often difficult to demonstrate as an independent muscle.

The *vastus internus muscle* is much smaller than the vastus externus, and arises by a narrow tendon from the internal border of the linea aspera, from the ridge extending to the internal condyle, and from the internal intermuscular septum, which separates it from the adductor muscles. It becomes quite thick as it descends, and its fibres pass obliquely to be inserted into the adjacent borders of the crureus and rectus muscles and into the inner border of the patella as far as its lower border. It is therefore fleshy to a lower extent than any of the other muscles forming the extensor group, and when in action produces the decided bulge above the knee at the inner side and lower part of the thigh. It receives its nerve from the anterior crural, and its blood from the internal muscular branches of the femoral artery.

The chief function of the mass of muscles constituting the quadriceps extensor group is to extend the leg upon the thigh and thus straighten the lower limb, as in walking or kicking. Acting from the leg, as in standing, the vasti and crureus act upon the femur, supporting it upon the head of the tibia, and, with the assistance of the rectus, thus maintaining the entire weight of the body. It should be observed that the vasti and crureus are attached to the femur only, while the rectus is attached by its double origin to the pelvis, so that the latter either flexes the thigh or draws the pelvis forward. The peculiar attachment of the vastus internus serves to draw the patella upward and inward in extending the knee, thus overcoming the tendency of the patella to outward dislocation (page 293). The sub-crureus pulls the synovial pouch out of the way of the patella during the extension of the knee. There is a quantity of loose connective tissue between the lower part of the shaft of the femur and the overlying muscles, which in cases of *synovitis of the knee-joint* allows the pouch to be distended to the extent of several inches above the patella and gives rise to the characteristic swelling of this affection.

The group of muscles extending along the inner side of the thigh from the pelvis to the femur are the **adductors**. They are the *gracilis*,

the *adductor longus*, the *pectineus*, the *adductor brevis*, and the ***adductor magnus***.

The *gracilis muscle* (Plate 87, No. 15) is the innermost, and is a long flat muscle arising by a ribbon-like tendon from the lower half of the border of the symphysis pubis and the adjacent margin of the descending ramus. Its fibres form a narrow slender mass terminating in a rounded tendon which passes over the internal lateral ligament of the knee-joint, behind the sartorius, and is inserted on the front of the tibia beneath the expanded tendon of the sartorius and above that of the semi-tendinosus. Through the greater part of its extent the gracilis is covered only by skin and fascia, and it produces the graceful outline of the inner side of the thigh. There is a bursa interposed between the knee and the tendons of the gracilis and semi-tendinosus muscles. The gracilis is supplied by the obturator nerve, and its arteries are from the internal circumflex and the femoral. Its action assists in adducting the thigh, and co-operates with that of the semi-tendinosus in rotating the leg inward when the knee is about to be bent. The *adductor longus muscle* arises by a narrow tendon below the crest of the pubis. Its fibres expand into a triangular mass which passes downward, outward, and backward to be inserted by short tendinous fibres into the internal intermuscular septum along the inner border of the lower two-thirds of the linea aspera. It rests upon the adductor brevis and adductor magnus muscles, and is covered by the skin, the fascia, and the sartorius muscle, forming with the latter the lower boundaries of Scarpa's triangle (page 254). It is supplied by the anterior division of the obturator nerve.

The *pectineus muscle* is separated from the adductor longus by a small space, in which usually appears a part of the adductor brevis. Its origin is from the anterior surface of the ilio-pectineal line and from the prolongation of Gimbernat's ligament, which covers it, and its fibres pass downward and outward to be inserted by a tendon into the line leading from the lesser trochanter to the linea aspera. Its deep surface is in close relation with the capsule of the hip-joint. Its nerve comes from the anterior crural. The *adductor brevis muscle* arises from the front of the body and ramus of the pubis, below the adductor longus and

the pectineus. It broadens as it descends to be inserted into the line between the lesser trochanter and the linea aspera and the contiguous upper part of the linea aspera. The adductor brevis rests upon the obturator externus (page 261) and the adductor magnus, and is supplied by the obturator nerve.

The *adductor magnus muscle* usually consists of two portions. The largest of these arises from the tuberosity of the ischium and from the contiguous portion of the ramus. Thence it descends as a broad muscular layer to be inserted into the internal intermuscular septum and into the adductor tubercle of the femur, a separate layer passing to the whole length of the linea aspera and to the ridge extending from it to the internal condyle. The latter is pierced at intervals by the perforating branches of the profunda femoris artery, each hole being crossed by specialized tendinous fibres (Plate 88).

The smaller portion of the adductor magnus (the *adductor minimus*) is triangular in shape, arises from the ramus of the ischium below the adductor brevis, and ends in a flat tendon which stretches across the back of the lesser trochanter to be inserted into the gluteal ridge of the femur, its lower border extending as far as the hole for the middle perforating artery. It is separated above from the quadratus femoris muscle by the terminal branch of the internal circumflex artery. The adductor magnus is supplied by the posterior division of the obturator nerve and by a branch from the great sciatic nerve. It should be noticed that all the adductor muscles are attached to the femur by flat tendons which are more or less connected.

The combined action of this group of muscles assists chiefly in balancing the pelvis steadily on the thigh, as in standing on one leg, or in reversing their action to adduct the thighs, at the same time causing them to rotate outwardly. In walking they also assist in drawing forward the lower extremity. The special action of the two adductor magnus muscles serves in horseback-riding to grip the saddle or the sides of the horse with the knees. The adductor longus and adductor brevis resemble the adductor magnus in their actions, but are more direct flexors of the thigh upon the pelvis, and of the pelvis upon the thigh.

Scarpa's triangle has already been referred to as the space upon the upper part of the thigh bounded by Poupart's ligament above, the sartorius muscle outwardly, and the adductor longus muscle inwardly. The point where the sartorius crosses the adductor, or the apex of the triangle, is generally ten centimetres, or about a hand-breadth, below the line of Poupart's ligament, and when the thigh is abducted and the leg flexed there is usually a depression upon the surface, noticeable in consequence of the slight elevation produced by the upper portion of the sartorius muscle (page 247). The floor of the triangular space consists of the ilio-psoas, pectineus, and adductor longus muscles, with, in the female, a part of the adductor brevis.

The relations of the contents of Scarpa's triangle should be very attentively observed (Plate 86). *At the base of the triangle* the relative positions are as follows. Close to the anterior superior spine of the ilium is the *external cutaneous nerve of the thigh.* Two and a half centimetres, or about an inch, from the spine toward the middle of the groin is the position of the *anterior crural* or *femoral nerve,* which descends upon the interspace between the iliacus and the psoas muscle. Close to the latter in the male, and in the female generally separated from it by eight millimetres, or one-third of an inch, is the *common femoral artery,* in the outer compartment of the femoral sheath, and by its inner side is the *common femoral vein,* in the middle compartment of the sheath, while the inner or lymphatic compartment of the sheath, called the *femoral canal* (page 97), is directly over the pectineus muscle. The position of the femoral artery at this locality is just below the middle of Poupart's ligament when the thigh is abducted. *At the middle of the triangle* the anterior crural nerve breaks up into a number of branches, most of which pass along the outer side of the femoral artery, while the *internal cutaneous* branch passes directly over it. The common femoral artery here divides into the superficial femoral and the deep or profunda femoral, and the common femoral vein receives the profunda vein and the internal saphenous vein. The middle of Scarpa's triangle practically corresponds to the termination of the funnel-shaped sheath of the vessels formed by the expansions of the ilio-psoas and

extra-peritoneal fasciæ (page 69), and to the lower border of the saphenous opening of the fascia lata (Plate 70, Fig. 1). *At the apex of the triangle* the superficial femoral artery is crossed by the internal cutaneous nerve, and is itself directly over its companion vein, which at this point begins to pass to the outer side of the artery, the relation which it subsequently holds in the lower part of the thigh (Plate 88, No. 45).

The femoral artery is the continuation of the external iliac artery (page 75). It commences over the ilio-pubic eminence, and passes from below the middle of Poupart's ligament to the apex of Scarpa's triangle, as above described. In this part of its course it is covered only by the skin, the superficial fascia containing the femoral lymphatic glands, the fascia lata, and the anterior layer of the femoral sheath, so that it can be seen pulsating when the lower extremity is extended, and can always readily be felt. It rests upon the ilio-pubic eminence, the ilio-psoas tendon, and the capsule of the hip-joint. At the apex of the triangular space the artery rests upon the adductor longus muscle, whence it continues as the superficial femoral to enter the aponeurotic canal formed by the expansion of oblique tendinous fibres from the adductor longus and the vastus internus. This is the *canal of Hunter*, and is of variable extent (Plate 87), usually beginning about the middle of the thigh, becoming stronger as it approaches the lowest part, and finally ending in a rounded cord, which is attached to the adductor tubercle of the femur. If this canal is carefully examined it appears to be a three-sided passage, its outer part being attached externally along the linea aspera, its anterior part being derived from the vastus internus, and its posterior part from the adductor longus and the adductor magnus. As the superficial femoral artery issues from the canal of Hunter, it passes through the tendon of the adductor magnus muscle and enters the popliteal space, becoming the popliteal artery (Plate 90, Fig. 4, No. 4).

The branches given off by the femoral artery in Scarpa's triangle are the *superficial epigastric*, the *superficial circumflex iliac*, and the *superficial pubic*, all of which pierce the cribriform fascia to pass to their distribution (page 95). Besides these there are several little twigs, the *saphenous branches*, which carry blood to the lymphatic glands about

the saphenous opening. The most important branch is the *profunda femoris artery* (page 260), which arises usually four centimetres, or about an inch and a half, below Poupart's ligament, from the outer and deeper surface of the common femoral. It is not, however, uncommon to find the origin of the profunda much higher or much lower than this, and it should be always carefully considered in the *operation for ligating the superficial femoral.* This operation is preferably done at the *apex* of Scarpa's triangle, so that the collateral circulation will be secured mainly by means of the profunda. The incision should be made with the thigh abducted and the leg flexed obliquely across the artery parallel with the course of the sartorius muscle, and it is well to secure the artery beneath that muscle, so as to be sure of avoiding the profunda. This can be readily done by drawing the sartorius downward over the superficial aponeurosis of the rectus muscle (page 248). Although the artery and the vein after leaving the funnel-shaped expansion and the upper part of Scarpa's triangle are each provided with a distinct sheath, they are very intimately associated with dense connective tissue, which should be noted, so as to avoid including both artery and vein in a ligature. This mistake is often observed in the operating-room upon the cadaver, and, although the distended condition of the vein during life will probably reveal its relation, it is a matter of no little importance, especially as the vein at the apex of the triangle is covered by the artery. Near the apex of Scarpa's triangle the superficial femoral gives off branches to the rectus and sartorius muscles. They may serve as guides to the artery, as they lead directly to it. The branches of the superficial femoral artery within Hunter's canal are chiefly *muscular arteries* to the surrounding muscles, and the *anastomotica magna artery,* which arises from the anterior surface of the femoral near its lower end. The anastomotica (Plate 88, No. 44) divides into a *superficial* and a *deep* branch. The former after passing through the fascia of the canal accompanies the internal saphenous vein between the tendons of the sartorius and gracilis muscles, and joins with the *articular rete* of the knee. The deep branch pierces the tendon of the adductor magnus, and passes along the inner side of the knee below the superficial branch,

with which it communicates after sending a branch across the femur above the patella.

The femoral vein within Hunter's canal is first at the outer side just after it enters from the popliteal space, and then it is behind the artery along the middle of the thigh as far as the apex of Scarpa's triangle, whence it passes upward along the inner side of the artery to the groin to empty into the external iliac vein. It receives, from below upward, the venæ comites of the muscular and profunda branches, and, at the saphenous opening, the internal saphenous vein (page 244), and the veins from the superficial fascia of the abdominal wall and the upper part of the thigh. It has three pairs of valves. The remarkable construction of Hunter's canal is evidently for the protection of the femoral vessels from pressure, as the action of the muscles serves to keep its wall stretched, and the explanation that the vein is emptied upward of its blood in walking by the alternate pressure and relief from pressure thus afforded does not really apply here any more than the similar condition exerted upon the deep-seated veins elsewhere, and probably not as much. It should be appreciated that the *vein* passes behind the artery to escape these very influences, and that the more elastic coats of the artery are better able to withstand them.

The ligation of the femoral artery within Hunter's canal is a much more difficult task than in Scarpa's triangle. The position of the vessels is very deep, being close to the bone. An incision should be made obliquely to the course of the artery, avoiding the internal saphenous vein, and the interspace between the vastus internus and adductor longus muscles sought for below the sartorius muscle. The internal saphenous nerve and superficial branch of the anastomotica artery will be usually seen piercing the aponeurotic sheath, and may be used as a guide in opening the canal upon a grooved director. The internal saphenous nerve descends within the canal directly over the artery, and the areolar connective tissue connecting the artery with the vein behind it is very dense, and must be carefully dissected before the artery-needle is passed. The operator will be relieved of much embarrassment by remembering to work toward the bone, and not too low down, in this operation. For

PLATE 85.

The spinal cord and nerves in position as they appear when the posterior portion of the skull and the laminæ and spinous processes of the entire vertebral column are removed. The dura mater is opened and reflected so as to expose particularly the cauda equina. The dissection also shows the deep relations of the kidneys, although they, as well as the liver, are somewhat lowered, owing to the body lying with the abdomen resting upon a block.

1. The occipital lobe of the left hemisphere of the cerebrum.
2. The superior longitudinal sinus.
3. The torcular Herophili.
4. The left vertebral artery where it turns in the groove on the atlas vertebra to enter the foramen magnum.
5. The left common jugular vein and carotid artery.
6. The left brachial plexus of nerves.
7. The left second rib.
8. The left scapula, with its sling of muscles drawn outward.
9. Portion of the dura mater of the spinal cord reflected.
10. The intercostal vessels and nerve between the left fifth and sixth ribs.
11. The left seventh rib.
12. The intercostal vessels and nerve between the eighth and ninth ribs.
13. The pia mater of the spinal cord.
14. The left ninth rib.
15. The ganglion on the posterior root of the eleventh dorsal spinal nerve.
16. The left tenth rib.
17. The spleen.
18. The left twelfth rib.
19. The left kidney.
20. The cauda equina.
21. The cords of the sacral plexus of nerves.
22. The filum terminale.
23. The gluteal vessels.
24. The great sciatic nerve.
25. The occipital lobe of the right hemisphere of the cerebrum.
26. The dura mater of the cerebrum.
27. The right lobe of the cerebellum.
28. The right vertebral artery.
29. The right common jugular vein and carotid artery.
30. The right brachial plexus of nerves.
31. The right second rib.
32. The dura mater of the spinal cord.
33. The right fifth rib.
34. The right scapula and its muscles drawn outward.
35. The right seventh rib.
36. The right ninth rib.
37. The ganglion on the posterior root of the eleventh dorsal spinal nerve.
38. The end of the spinal cord.
39. The right eleventh rib.
40. The first lumbar spinal nerve.
41. The liver.
42. The right kidney.
43. The ganglion of the fifth lumbar nerve.
44. The crest of the right ilium.
45. The ganglion of the coccygeal nerve.
46. The right gluteal vessels.
47. The right sciatic nerve.

practical purposes it may be well to bear in mind that Scarpa's triangle occupies the upper third of the thigh, and Hunter's canal the middle third, while the lower third corresponds to the popliteal space.

The collateral circulation after ligation of the superficial femoral artery is established through the deep branch of the anastomotica magna artery, bringing blood from the descending branches of the internal circumflex, and from the anastomoses between the muscular branches of the femoral artery below the ligature and those above it; by the superior muscular branches of the popliteal artery connecting with the lower perforating arteries, and chiefly with the arteria comes nervi ischiatici (page 227), and by the superior external articular arteries anastomosing with the descending branches from the external circumflex.

The anterior crural or femoral nerve (Plate 63, No. 23) is formed by the posterior divisions of the lumbar plexus (page 78), of which it is the largest branch, and descends between the iliacus and psoas muscles below Poupart's ligament into the upper part of Scarpa's triangle. Before leaving the pelvis the anterior crural sends branches to the adjacent muscles, a few filaments which wind about the femoral artery, probably contributing its vaso-motor influences, and a branch to the pectineus muscle. The latter branch is sometimes augmented by an internal cutaneous branch, which issues from the pelvis beneath the femoral vessels and then divides to go to the pectineus muscle and to the skin of the inner side of the thigh. It has been called the *accessory obturator nerve* because occasionally it communicates with the obturator nerve (page 262) and sends a filament to the hip-joint. The anterior crural in Scarpa's triangle gives off branches which are distributed to the skin over the front of the thigh, the *middle cutaneous nerve* (Plate 86, No. 11, and Plate 70, Fig. 1, No. 9), and to the sartorius, rectus, and external vastus muscles, from which articular filaments are prolonged to the knee, also branches to the crureus and internal vastus muscles. The latter enters Hunter's canal beneath the femoral vessels, and they both also furnish filaments to the knee, the nerve from the internal vastus to the joint being especially large. The last branch from the anterior crural is called the *internal saphenous*

nerve, because it accompanies the internal saphenous vein. In relation to the tendons of the sartorius and gracilis it gives off *articular* and *patellar nerves* (Plate 90, Fig. 1, No. 4). In some instances this nerve passes completely around the tendon of the sartorius muscle, as is shown in Plate 90, Fig. 3, No. 12. Below the knee it supplies the skin of the inner side of the leg (page 303) and descends as far as the ball of the great toe.

The profunda femoris artery arises from the outer and posterior surface of the common femoral artery, as already described (page 256), and gives off the following branches. The *external circumflex artery* passes outward through the branches of the anterior crural nerve over the iliacus muscle and beneath the sartorius. From it arise branches which go respectively to the rectus, crureus, and vastus externus muscles, and communicating branches with the gluteal artery and the crucial anastomosis (page 227). Occasionally there is a large branch from the external circumflex which descends along the anterior border of the external vastus toward the knee. In a case of stab-wound, the author found considerable difficulty in arresting the hemorrhage from this artery. The *internal circumflex artery* usually arises from the profunda about opposite the external. It passes inward and backward between the psoas and pectineus muscles, then between the obturator externus and adductor brevis muscles, and finally terminates in the gluteal region at the upper border of the quadratus muscle (page 225). It distributes arteries to the neighboring muscles, and an important branch which enters the hip-joint beneath the transverse ligament to the substance of the ligamentum teres and the head of the femur (page 230). One of the terminal branches of the internal circumflex artery joins the crucial anastomosis. It should be remembered that in cases of low origin of the profunda the circumflex arteries arise from the common femoral.

Below the adductor longus muscle the profunda artery gives off the *first perforating artery*, which pierces the tendon of the adductor brevis close to the femur (Plate 88, No. 35) and divides into an ascending branch, to join the crucial anastomosis, and a descending branch, which supplies the muscles on the back of the thigh and anastomoses with

the *middle perforating artery.* The latter, usually the largest of all the perforating arteries, leaves the profunda close to the lower border of the adductor brevis muscle, pierces it, and divides into an ascending and a descending branch. It is important, as it usually furnishes the principal *nutrient artery* to the femur, which enters the nutrient foramen above the middle of the linea aspera and passes in a canal directed obliquely upward to open into the medullary cavity. The *inferior perforating artery* arises over the adductor magnus close to the femur, penetrates backward, and chiefly supplies the short head of the biceps muscle (page 263). The profunda also distributes a few muscular twigs, and terminates in what is sometimes called the *fourth perforating artery,* which pierces the lower part of the adductor magnus tendon, and, after supplying the biceps muscle, anastomoses with the internal articular branch of the popliteal artery. The different branches of the profunda artery are each accompanied by venæ comites, which unite eventually into one trunk, the *profunda vein,* which empties into the femoral vein between the femoral and profunda arteries. The profunda vein is provided with from three to five pairs of valves.

The *obturator externus muscle* is deeply situated at the upper part of the thigh, and arises from the obturator crest of the pubes above the obturator foramen by a small upper portion and by a lower larger portion, from the surface of the inner part of the obturator membrane, from the contiguous border of the ischio-pubic rami, and from the tendinous arch over the obturator vessels. Its fibres form a triangular mass converging to a tendon which passes backward and outward across the back of the hip-joint to be inserted into the digital fossa under the quadratus femoris muscle. It receives a nerve from the posterior division of the obturator nerve. This muscle assists the adductor muscles and serves to rotate the thigh outward. It is regarded as a segmentation of the adductor mass of muscles.

The obturator nerve (Plate 63, No. 20) is derived from the anterior divisions of the second, third, and fourth nerves of the lumbar plexus (page 78). It escapes from the obturator canal, formed of the pelvic fascia (page 126), and, after giving off a branch to the obturator

externus muscle, divides into anterior and posterior divisions. The *anterior obturator nerve* (Plate 88, No. 21) is distributed to the adductor brevis and adductor longus muscles and to the gracilis. Occasionally it sends a twig to the pectineus. It also sometimes sends a branch to the hip-joint near its origin. The *posterior obturator nerve* passes between the upper and lower portions of the obturator externus muscle, and sends a branch to the hip-joint and branches to the several parts of the adductor magnus muscle. The nerves to the adductor magnus distribute fine branches to the nutrient foramen of the femur, and along the posterior surface of the popliteal artery to the back of the knee-joint (page 288).

The obturator artery arises from the anterior branch of the internal iliac artery (Plate 76, Fig. 1, No. 18), and, after passing through the obturator canal, appears on the thigh beneath the adductor longus muscle, where it divides into two branches. The outer branch passes to the hip-joint, which it enters beneath the transverse ligament with the branch from the internal circumflex artery (page 233). The outer branch is distributed to the obturator externus and adductor brevis muscles.

The back of the thigh may be considered as extending from the gluteal fold to the popliteal space. When the skin and outer layer of the superficial fascia are removed, the *posterior superficial veins* will be seen passing across the thigh to join the internal saphenous vein (Plate 89, Fig. 1, No. 24), and the several *cutaneous branches of the small sciatic nerve* upon the inner and middle portions of the thigh, with the terminal branches of the posterior division of the external cutaneous nerve upon the outer (Plate 89, Fig. 1, No. 27).

The *fascia lata* in this locality consists of a strong superficial layer of transverse or oblique fibres over a deeper layer of longitudinal fibres. The continuation of the *lesser sciatic nerve* (page 156) passes between the fascia lata and the muscular aponeurosis along the middle of the back of the thigh to the *hiatus saphenus posterius,* where it becomes superficial and supplies the skin over the popliteal space (page 284). Upon removal of the fascia lata the flexor muscles, which bend the leg and are called the *hamstring muscles,* are brought into view (Plate 89, Figs. 1 and 2).

They all arise from the tuberosity of the ischium. The *biceps femoris muscle* arises by a long tendinous head from the greater sciatic ligament and the upper part of the tuber ischii below the lesser sciatic notch, in close connection with the semi-tendinosus. It soon becomes fleshy, and at the lower third of the thigh blends with the fibres from the short head, which arise directly from the outer border of the linea aspera, beginning below the gluteus maximus muscle, between the vastus externus and the adductor magnus, and extending along the supra-condyloid ridge to within an inch of the condyle. The common tendon resulting from the union of these two portions is inserted into the upper and back part of the styloid process of the fibula, after being separated into two parts by the external lateral ligament of the knee-joint (Plate 91, Fig. 2, No. 4). A strong expansion from the tendon passes to the fascia over the outside of the leg. The long head receives its blood from the perforating branches of the profunda artery, and the short head from the muscular branches to the adjacent vastus externus. Both heads of the biceps are supplied by the great sciatic nerve, or in case of its high division the long head receives its nerve from the popliteal division and the short head a branch from the peroneal division. The biceps serves to flex the knee or to extend the hip. When the knee is bent it also causes the leg to rotate outward. In chronic knee-joint disease this action is manifest, the leg even becoming dislocated outward and backward.

The *semi-tendinosus muscle* arises conjointly with the biceps from the tuber ischii. It soon forms a fleshy mass, in the midst of which there is a tendinous intersection, which appears on the surface irregularly and, from the middle of the thigh, continues downward as a long round tendon to be inserted into the upper part of the inner surface of the tibia below the tendon of the gracilis and beneath the tendon of the sartorius. This muscle is supplied by the popliteal division of the great sciatic nerve.

The *semi-membranosus muscle* arises from the upper and outer facet on the tuber ischii, above and to the outer side of the biceps and semi-tendinosus muscles, by a strong flat tendon. This tendon descends obliquely nearly half-way down the thigh beneath the other muscles,

and ends in a large fleshy mass, which is inserted principally into the inner and back part of the internal tuberosity of the tibia by a thick tendon. From the tendinous insertion an auxiliary fasciculus extends under the internal lateral ligament of the knee, a bursa being interposed between them, and from its posterior surface another expansion extends across to the back of the external condyle of the femur, thus forming the chief portion of the posterior ligament of the knee-joint. It further gives off an expansion which firmly embraces the popliteus muscle, and by its connections also serves to keep the semilunar fibro-cartilages of the knee in place when that joint is moved. There is a large bursa between the tendon of insertion of the semi-membranosus and the inner head of the gastrocnemius muscle, which in many cases communicates indirectly with the synovial membrane of the knee-joint. The semi-membranosus is supplied by muscular branches from the popliteal artery and the perforating branches from the profunda. Its nerves are derived from the great sciatic nerve.

The *actions of the hamstring muscles* serve to flex the leg upon the thigh. They are peculiar in that they are too short to allow of full flexion of the hip while the leg is extended. They possess what is called the "ligamentous function," owing to their attachments passing over the two joints of the hip and the knee. Thus, when the pelvis is fixed, the thigh can be only moderately flexed while the knee is straight, but as soon as the knee is flexed the hamstring muscles are relaxed and the thigh can be entirely flexed. Acting from below, these muscles serve to support the pelvis upon the head of the femur, preventing the trunk from falling forward. This is well shown in feats of strength where the body is thrown backward. When the knee is semi-flexed the biceps rotates the leg slightly outward, owing to its oblique direction downward and outward; and in the same way the semi-tendinosus and semi-membranosus can assist the popliteus in rotating the leg inward.

The tendons of the hamstring muscles as they respectively pass to their insertions form the boundaries of the upper portion of the *popliteal space* (page 284), the biceps tendon being upon the outer side and the tendons of the semi-membranosus and semi-tendinosus on the inner.

The great sciatic nerve below the gluteal fold rests upon the adductor magnus muscle under cover of the long head of the biceps muscle. It occupies the middle line of the thigh. Its division into the *popliteal* and *peroneal nerves* may take place at any point below its origin (page 227) and the lower third of the thigh. In those cases in which the division occurs within the pelvis, these nerves surround the pyriformis muscle (page 224), and afterward pass downward side by side, connected by loose areolar tissue.

Fractures of the femur most commonly occur about the middle of the shaft. When due to direct violence the breach in the bone is usually transverse, while from indirect violence it is usually oblique. The displacement of the fragments in a fracture at the middle of the bone depends greatly upon the direction and nature of the violence producing it and the resulting degree of obliquity of the fracture. It will be generally found that the lower fragment is drawn upward behind the upper fragment, in consequence of the united contraction of the three hamstring muscles, the tensor fasciæ femoris, the rectus, the gracilis, and the sartorius, with the adductors. The latter also have a tendency to draw it to the inner side, thus increasing the natural outward inclination of the foot and leg, which are further everted chiefly by their own weight. The lower end of the upper fragment is, as a consequence of the direction of the lower fragment, usually tilted outward at the same time that it projects forward.

In childhood not only is the line of fracture through the middle of the femur generally transverse, but there is also very little displacement of the fragments, in consequence probably of the stronger character of the periosteum, which is not so liable to be lacerated with the occurrence of the breach in the bone during the period of active growth as it is after the full stature has been attained. In young children this injury is not attended with eversion of the leg and foot of the affected limb, partly because of the comparative shortness of the neck of the thigh-bone, and partly because the external rotator muscles have not yet been brought into habitual exercise in maintaining the equilibrium in the erect position.

PLATE 86.

The skin and superficial fascia removed from the anterior surface of the right thigh to show the superficial vessels and nerves upon the fascia lata, while upon the left the anterior group of muscles are dissected so as to show the boundaries and contents of Scarpa's triangle (in the male).

1. The right external cutaneous nerve.
2. The right iliacus muscle.
3. The obturator nerve.
4. The anterior superior spinous process of the ilium.
5. The right anterior crural nerve.
6. The right sacral plexus.
7. The cut ends of the femoral artery and vein.
8. Branches of the external cutaneous nerve.
9. The iliac portion of the fascia lata.
10. The pubic portion of the fascia lata.
11. Branches of the middle cutaneous nerve.
12. Branches of the genito-crural nerve.
13. Branches of the internal cutaneous nerve.
14. The internal femoral cutaneous vein.
15. The penis.
16. The fascia lata.
17. The long or internal saphenous vein.
18. Branches of the internal articular arteries.
19. The bursa patellæ.
20. The internal saphenous vein and nerve.
21. The lower portion of the abdominal aorta.
22. The inferior vena cava.
23. The left common iliac artery,
24. The left external cutaneous nerve.
25. The left common iliac vein.
26. The gluteus medius muscle.
27. The psoas magnus muscle.
28. Remnant of Poupart's ligament.
29. The left anterior crural nerve.
30. The deep circumflex iliac artery.
31. The tensor vaginæ femoris muscle.
32. The anterior crural nerve.
33. The femoral artery.
34. The femoral vein.
35. The pectineus muscle.
36. The apex of Scarpa's triangle.
37. The adductor longus muscle.
38. The rectus femoris muscle.
39. The gracilis muscle.
40. The sartorius muscle.
41. The vastus internus muscle.
42. The aponeurotic cap to the knee.

Plate 86

38

39

40

42

Dissected, Photographed and Colored from Nature by George McClellan, M.D.

The natural eversion of the foot in the adult should never be mistaken for the result of muscular action, for it persists during sleep or anæsthesia, when the consciousness and muscular action are both suspended. One of the most distinctive signs of fracture is the *shortening of the limb.* The amount of shortening is due to the elastic contraction of the soft parts and the degree of overlapping of the fragments of the broken bone. In the treatment of this form of fracture, in spite of all the mechanical ingenuity and the various methods of extension and counter-extension which have been practised, it is very rarely that the shortening is entirely overcome. It should be noted in this connection that the *normal lengths of the right and left lower limbs* are not always identical, and careful observations made both upon the sound living body and upon the skeleton have shown that the greatest variance occurs in the femur. It is usually considered to be a good result after treatment if the injured limb is found to be shortened not more than two centimetres, or three-quarters of an inch.

In taking measurements for the purpose of ascertaining the degree of shortening, it is essential that the patient's body should be resting upon a firm, unyielding surface, with the pelvis so placed that a line drawn between the anterior superior spinous processes of the two iliac bones will bisect at right angles the straight line of the body. This being assured, either the measurement may be made from the umbilicus to the inner malleolus of one leg and then to that of the other, or the tape-line may be held by the patient with his teeth, while his head is immovably held in the straight line of the body, and the length to the inner malleolus of one leg compared with the length to the inner malleolus of the other (Keen). The author ventures to remark that he has frequently observed that in the treatment of fractures of the thigh the measurements for shortening constitute by far too prominent a feature, and that the manipulations attendant upon them seriously interfere with the maintenance of the proper adjustment of the fracture-dressings upon which the result, including the diminution or possible counteraction of the tendency to shortening, depends.

A fracture in the upper third of the femur below the lesser trochanter

is always attended with considerable deformity and shortening. The upper fragment is tilted forward by the ilio-psoas, pectineus, adductor brevis, and gluteus minimus muscles, and by the pressure of the lower fragment, which is drawn upward by the muscular action and general elastic retraction of the soft structures, described above in relation to a fracture occurring at the middle of the shaft. The overlapping of the fragments is so difficult to contend with that it is perhaps well for surgeons to consider that, as the double inclined plane and traction upon the lower fragment of the femur in the flexed position so rarely produce satisfactory results, the best method of dealing with the injury may be to cut boldly down and wire the fragments together. Fortunately, fractures in the upper third of the shaft of the femur are less common than in any other part of the bone. They are almost always the result of indirect violence.

Fractures of the lower end of the femur occur usually just above the condyles, and are very troublesome to set properly, owing to the lower fragment being drawn upward by the same agencies as in other fractures of the shaft, aided by the gastrocnemius muscle, so that its sharp end impinges upon the popliteal space. Extension applied to the leg increases the latter condition. Division of the tendo Achillis in these cases has been suggested and found practicable as a means of restoring the fragments to their proper position, by eliminating the resistance of the gastrocnemius muscle. The proximity of the fracture to the point where the femoral artery turns round the bone to become the popliteal artery naturally endangers that vessel, and this fact should be remembered in the manipulation of the fragments of such a fracture.

In *amputation through the middle of the thigh* by the antero-posterior flap method (Plate 95, Fig. 2), the relations of the parts as exposed upon the *right* side are as follows:

In the anterior flap are the divided rectus muscle (No. 1), directly over the shaft of the femur (No. 3), with the vastus externus muscle (No. 4) on the outer side and the vastus internus and crureus muscles (No. 12) on the inner side. The internal saphenous vein (No. 10) is upon the inner margin of the anterior flap, as are also the middle and

internal cutaneous nerves. The femoral artery (No. 13) and the femoral vein (No. 14) are between the vastus internus and adductor longus muscles, the vein being nearer the bone in this part of the thigh. Perforating branches of the profunda femoris artery (No. 5) are close to the under surface of the bone. The great sciatic nerve (No. 6) is separated from the under surface of the bone by a layer of cellular tissue. Upon the face of the anterior flap will be found the descending branches of the external circumflex artery and several perforating arteries and muscular nerves. The posterior flap is composed chiefly of the divided hamstring muscles, in the centre of which the tendon of the semi-membranosus muscle (No. 8) is conspicuous. In the posterior flap will be found branches of the lower perforating arteries and the small sciatic nerve. The obturator nerve is near the inner angle between the flaps. The periosteum of the femur is usually thick and easily reflected from the bone, and it is often advisable to detach it in the form of an anterior flap (No. 2) before sawing the bone.

If the periosteal flap is adjusted over the medullary canal, when the flaps are approximated it affords an excellent protection against absorption of septic matter by the veins of the Haversian canals. In all amputations care should be taken not to leave the periosteum jagged beyond the line of section of the bone, as bony spiculæ are liable to form and may occasion a painful stump in consequence of their irritating influence upon the ends of the severed nerves in the flaps.

The *development of the femur* begins in the third week of fœtal life, by the formation of a rod of cartilage. It is the next after the clavicle in the fœtus to begin to ossify, a centre of ossification first appearing in the middle of the cartilaginous mould of the shaft about the seventh week. The centre for the lower epiphysis begins just before birth and forms the condyles. The head of the femur begins to ossify about the tenth month after birth, the greater trochanter in the fourth year, and the lesser trochanter between the thirteenth and fourteenth years. The *epiphyses* are not joined to the shaft until after puberty: the first, being the lesser trochanter, at the eighteenth year, the next, the greater trochanter, about six months later, the next, the head, at the nineteenth

year, and the lower extremity (which is the first to show ossification, and is peculiar for being the only epiphysis in the body in which ossification begins before birth) at the twenty-first year. On account of the length of time which the lower epiphysis requires to complete its ossification, the growth of the femur is greatest in the lower part of the shaft.

In operating for knock-knee or for bow-leg it is important to avoid interfering with the epiphyseal cartilage, so as not to modify the growth of the limb.

A longitudinal section of the femur reveals the arrangement of the structure of the bone which admirably adapts it to the support of the weight of the body with the greatest mechanical advantage. This is particularly interesting in the disposition of the fibres of the cancelli in the upper end, where one series of parallel fibres passes vertically from the top of the head to the lower part of the neck, while another series of fibres passes transversely from the upper part of the neck across the vertical fibres. The base of the neck is composed chiefly of a series of arching fibres so arranged that they extend across from the base of the greater trochanter to the upper part of the neck and thence to the lower part, where the neck merges into the lesser trochanter. The vertical fibres are in the direction of the greatest pressure, while the transverse and arching fibres are in the direction of the greatest tension. The shaft of the femur is a cylinder of compact tissue enclosing a large medullary canal, which is most completely formed in the middle third of the bone. Here the compact tissue is of greatest thickness and density, but it gradually becomes thinner toward the upper and lower ends, owing to the separation of the layers of the bone into cancelli. The cancellated tissue constitutes the bulk of the two ends of the bone, and is provided with a thin, compact layer upon the articular surfaces. In the lower end of the femur the directions of the cancelli are vertical and horizontal, intersecting one another at right angles.

The head of the femur receives a nutrient artery from the obturator artery, which enters within the structure of the ligamentum teres (page 232), and the greater trochanter receives a nutrient artery from the

internal circumflex. The nutrient artery for the shaft, the *medullary artery*, is a branch of the middle perforating artery (page 261), and enters near the middle of the linea aspera, passing in an oblique direction upward. The nutrient arteries to the condyles are branches of the superior articular arteries.

THE REGION OF THE KNEE AND THE POPLITEAL SPACE.

The bones which constitute the **knee** are the lower end of the femur, with the patella superposed upon its condyles, and the upper end of the tibia. The peculiar conformation of the lower end of the femur has already been described (page 241). The *patella*, or *kneepan*, is a flattened triangular bone placed with its apex downward in front of the knee, and so disposed that its lower articular surface rests upon the trochlea of the femur to a variable extent, depending upon the degree of extension or flexion of the knee-joint. The anterior surface of the patella appears striated longitudinally, slightly convex, and perforated for the passage of nutrient vessels. In the recent state it is covered by an expansion from the tendon of the extensor quadriceps muscle which becomes continuous with the superficial fibres of the ligamentum patellæ below, and it is separated from the skin by the large *bursa patellæ*. Careful dissection shows that this bursa is in reality formed of two sacs, one between the skin and the superficial fascia near the lower margin of the patella, which is usually small, and another between the superficial fascia and the expansion of the deep fascia, which is the larger and extends over the upper part of the ligamentum patellæ. These *pre-patellar bursæ* generally communicate, and they probably always do so when enlarged by constant pressure, as in *housemaid's knee*. In the female the patella is proportionately wider than it is in the male. The posterior surface of the patella is covered by articular cartilage, except at the lower angle, where it is rough for the attachment of the ligamentum patellæ. The articular surface is oval, and is divided by a vertical ridge into two facets, of which the *outer* is the

larger. In a well-marked specimen this surface is further subdivided by two transverse ridges which pass laterally from the vertical ridge, so that there are six shallow facets, each of which is brought into contact with a definite part of the trochlear surface of the femur in the different positions of the joint. It should be understood that the whole of the articular surface of the patella is never in contact with the femur. The greatest extent to which the bony surfaces are brought in apposition occurs when the joint is in the mid-position between extension and flexion. Then the middle and largest sub-facets of the patella are in contact with the femur. In extreme extension only the inner border and a small area on each side of the vertical ridge at its lower part are in contact with the trochlea, while in extreme flexion only a small area on each side of the upper part besides the inner border is in contact. The inner border of the patella is separated from the rest of the articular surface by an indistinct line, and is in contact with the femur in all positions. The lateral borders of the patella are much thinner than the middle of the bone, and as they converge below they give attachment to the tendinous expansion called the capsule of the knee, and to part of the tendons of the external and internal vasti muscles. The upper border of the patella is comparatively thick, and receives the insertion of the tendons of the rectus and crureus muscles. When the leg is extended and the foot rested, so that there is no strain upon the quadriceps muscle, the patella is freely movable. Its varying positions and relations should be carefully studied in every case of injury or disease of the knee, and careful comparison made with the corresponding bone of the opposite limb, which is at all times a ready and valuable guide for reference. The patella consists of dense cancellous tissue covered by a thin layer of compact tissue, and is regarded as a large sesamoid bone. It begins to ossify about the end of the second year. Its function, besides the affording of protection to the front of the knee-joint, is to increase the leverage of the quadriceps extensor muscle, enabling it to act at a greater angle.

The *upper end* or *head of the tibia* is about twice as broad as the lower end. It consists of an *outer* and an *inner tuberosity*, which are

separated posteriorly by the shallow *popliteal notch.* The upper surfaces of the tuberosities are smooth and concave for articulation with the condyles of the femur. The internal is narrower, longer, and deeper than the external, and is of oval shape, while the external is broader and flatter, and is more circular in shape. Between the two articular surfaces is the *spinous process,* which is an irregularly-bifid projection and in the recent state affords attachment on either side to the cornua of the semilunar fibro-cartilages which serve to deepen the articular surfaces. In front of and behind the spinous process are depressions for the anterior and posterior crucial ligaments. Anteriorly the two tuberosities are continuous with each other, forming a rough prominent surface which is somewhat flattened and perforated by many vascular foramina. Two and a half centimetres, or about an inch, below the articular surfaces the bone presents a prominent oblong elevation, the *tubercle,* the lowest part of which is roughened for the attachment of the ligamentum patellæ, a bursa being always interposed between the ligament and the upper part of the tubercle. The internal tuberosity is marked posteriorly by a groove for the tendon of the semi-membranosus muscle. The external tuberosity has a slight projection forward for the insertion of the ilio-tibial band (page 245), and below and behind it presents a small articular facet for the head of the fibula.

The knee-joint is a modified ginglymus or hinge joint, but wholly unlike the elbow. The bones which enter into its formation, as they appear in the ordinarily-prepared skeleton, give an idea of insecurity which would be altogether opposed to the proper performance of its function in admitting extension and flexion and sustaining the body-weight. The insecurity arising from the deficiency in the adaptation of the bony surfaces is compensated for by the remarkable arrangement of the peculiar ligaments of the joint, as well as by the expansions from the many powerful tendons which pass over it and constitute its main protection.

The knee is both the largest and the most complicated of all the articulations. It may be considered as consisting primarily of two joints, the *femoro-tibial* and the *femoro-patellar,* which are morphologically dis-

tinct, corresponding to the arrangement found in some of the lower animals. In man, however, the two joints are inseparable.

The ligaments connecting the bones of the knee are placed both within and without the joint. Those upon the outside are the anterior, internal lateral, long and short external lateral, posterior, and capsular ligaments. The *anterior ligament*, or *ligamentum patellæ*, is placed in front beneath the skin and the fasciæ, and consists of a strong, flat band of fibres extending from the apex of the patella to the lower part of the tubercle of the tibia. This ligament is in reality a continuation of the tendinous fibres from the muscles composing the quadriceps extensor muscle, in which the patella is developed as a large sesamoid bone. Several layers of fibres can be separated from the attachments of the vasti tendons upon each side of the patella which merge with the capsule and become attached to the respective borders of the tibia. These are sometimes called the *lateral patellar ligaments*. As already stated, there is a synovial bursa interposed between the head of the tibia and the upper part of the proper ligamentum patellæ, which prevents the effect of friction in the exercise of the joint. Besides this there is a pad of fat between the ligament and the front of the joint, which when well developed produces a bulging elastic mass on each side of the ligament, and is especially pronounced when the knee is extended.

The *internal lateral ligament* is a broad, flat band arising from the internal epicondyle of the femur near the adductor tubercle, where it was originally continuous with the tendon of the adductor magnus muscle. Its fibres diverge as they pass over the middle of the joint, and become attached to the internal tuberosity and the contiguous part of the shaft of the tibia. Its deep surface is partially united to the capsule, and also to the internal semilunar fibro-cartilage, thereby serving to keep it in place. Posteriorly it bridges over the tendon of the semimembranosus, below which it crosses the internal inferior articular artery and nerve and then blends with the fascial sheath of the popliteus muscle. This ligament is crossed superficially at its insertion by the tendons of the sartorius, gracilis, and semi-tendinosus muscles, a synovial bursa being interposed.

The *long external lateral ligament* is a round cord surrounded by the tendon of the biceps muscle, extending from the outer epicondyle of the femur to the outer part of the head of the fibula, where it was originally continuous with the attachment of the peroneus longus. It overlies the tendon of the popliteus muscle and the inferior external articular artery and nerve.

The *short external lateral ligament* is an accessory band extending from the condyle of the femur behind the long ligament to the tip of the styloid process of the fibula. It also crosses the tendon of the popliteus, and is intimately connected with the capsule.

The *posterior ligament* (generally called the *ligamentum posticum Winslowii*) underlies the popliteal vessels, and extends as a broad, perforated band from above the condyles and intercondyloid notch of the femur to the posterior border of the head of the tibia. It essentially consists of a middle and two lateral portions, the latter being composed of vertical fibres united to the tendons of the gastrocnemius, plantaris, and popliteus muscles, while the middle portion is composed of obliquely decussating fibres separated by various apertures for the passage of vessels, the apertures for the azygos artery and the articular branch of the obturator nerve being especially noteworthy. The strongest part of the posterior ligament is derived from the tendon of the semi-membranosus muscle.

The *capsular ligament of the knee* is hardly deserving of a special designation, since it is incomplete as a capsule and does not possess the function of a ligament. It consists of expansions from the tendons of the muscles which pass on each side of the joint blended with the investing femoral fascia and with the other ligaments of the outer series. It is incomplete anteriorly, as it does not extend beneath the extensor tendons, owing to the intervention of the patella. It is inseparable from the posterior ligament in the floor of the popliteal space. In the intervals between the other ligaments the capsule is weak, so that when the joint is distended with fluid it allows of a swelling on each side of the ligamentum patellæ, which, however, should not be confounded with the bulging of the fat in this locality (page 274).

PLATE 87.

Deep dissections of the anterior of the thigh. The sartorius muscle is removed on both sides to show the arrangement of the aponeurotic investment of the femoral vessels, called the canal of Hunter.

1. The cut end of the tensor vaginæ femoris muscle turned upward.
2. The cut end of the sartorius muscle turned upward.
3. The middle sacral artery.
4. The cut end of the gluteus medius muscle turned upward.
5. The right sacral plexus.
6. The gluteus minimus muscle.
7. The right femoral artery.
8. The right anterior crural nerve.
9. The right femoral vein.
10. The pectineus muscle.
11. The external circumflex artery.
12. The adductor longus muscle.
13. The penis.
14. Branch of the middle perforating artery.
15. The right gracilis muscle.
16. The right rectus muscle drawn outward.
17. The nerves to the vastus internus muscle.
18. The adductor magnus muscle.
19. The opening into Hunter's canal upon the right side.
20. The vastus internus muscle.
21. Branches of the internal articular artery.
22. The abdominal aorta.
23. The inferior vena cava.
24. The left common iliac artery.
25. The left common iliac vein.
26. The cut end of the left tensor vaginæ femoris muscle.
27. The cut end of the left sartorius muscle.
28. The deep circumflex iliac artery.
29. The remnant of Poupart's ligament.
30. The iliacus muscle.
31. The left anterior crural nerve.
32. The pectineus muscle.
33. The nerves to the vastus externus muscle.
34. The adductor longus muscle.
35. The nerves to the vastus internus muscle.
36. The left rectus femoris muscle.
37. The opening into Hunter's canal on the left side.
38. The adductor magnus muscle.
39. The left gracilis muscle.
40. The vastus internus muscle.
41. The tendons of the semi-tendinosus and gracilis muscles curving forward to their insertions upon the tibia.

(N.B.—Both thighs are everted and placed in the proper position for the operation of ligating the femoral artery.)

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Dissected, Photographed and Colored from Nature by George McClellan, M.D.

The ligaments within the knee-joint are the ligamenta alaria, the ligamentum mucosum, the transverse, the two crucial, the two semilunar fibro-cartilages, and the coronary. When the joint is opened from in front, the fatty cushion beneath the upper part of the ligamentum patellæ is brought into view, together with a crescentic fold of the synovial membrane upon each side of it, extending upward along the lateral borders of the patella and indicating the limits of the deficiency in the capsule. These folds are called the *alar ligaments.* Besides these there is a weak fold of the synovial membrane which passes from the middle of the fatty cushion to the front of the intercondyloid notch of the femur, constituting the *ligamentum mucosum.* This fold serves to draw upward the sub-patellar fatty cushion beneath the patella when the limb is flexed, the ligamentum patellæ drawing it forward in extension. On the front of the head of the tibia is the *transverse ligament,* which is variably developed and extends from the front of one semilunar cartilage to that of the other.

The crucial ligaments can be properly seen only upon removal of the other structures within the joint. They are called crucial because they cross each other like the letter X. The *anterior crucial ligament* is attached above to the back and inner part of the outer condyle of the femur, and below to the front of the spine of the tibia between the anterior cornua of the semilunar cartilages. The *posterior crucial ligament* is attached above to the front and outer part of the inner condyle, and descends nearly straight to the back of the spine of the tibia, dividing into two slips. One of these is inserted behind the posterior cornu of the internal semilunar cartilage, the other (the *ligament of Wrisberg*) being inserted at the posterior border of the external semilunar cartilage. These ligaments co-operate with the lateral ligaments in limiting rotation, especially rotation inward. The crucial ligaments are rendered tense in extension of the limb, in consequence of their position behind the axis of motion.

The *semilunar fibro-cartilages* are crescentic disks attached to the margins of the head of the tibia. The outer border of each cartilage is thick and convex, the inner border being thin and concave and

directed inward toward the centre of the corresponding articular surface of the tibia. The *external semilunar cartilage* forms nearly a circle; its two extremities or cornua are enclosed by those of the internal semilunar cartilage, and firmly attached to the depressions in front of and behind the spinous process of the tibia; the anterior cornu is attached at the outer side of the anterior crucial ligament. It is grooved upon the outer surface for the tendon of the popliteus muscle, which separates it from the external lateral ligaments, and therefore the external semilunar cartilage is more liable to dislocation than the internal. The *internal semilunar cartilage* is semi-elliptical, being elongated from before backward. It is broader behind than in front, and its surface is in close connection with the internal lateral ligament. Its anterior cornu is pointed and attached internally to the anterior crucial ligament, and its posterior cornu is attached to the depression back of the spinous process in front of the posterior crucial ligament. The anterior surfaces of both semilunar cartilages are usually connected by the transverse ligament, already described, although that band is sometimes absent. Their convex lateral borders are connected with the subjacent borders of the head of the tibia by the so-called *coronary ligaments*, which have been usually so specialized, although they are merely the parts of the capsules artificially separated in opening the joint.

In amputation at the knee-joint it is often noticeable that the connection between the semilunar cartilages and the femoral condyles is greater than that between them and the head of the tibia, so that after severing the ligamentum patellæ the condyles are exposed with the semilunar cartilages attached to their outer borders. When this is the case they should be dissected from their attachments before closing the flaps of the amputation, as otherwise they might prolong the process of exfoliation and act like foreign bodies in the wound.

The *synovial membrane* of the knee is the most extensive synovial membrane in the body. It lines the articular cartilages of the bones forming the joint, and is reflected upon the articular surface of all the ligaments and tendinous expansions surrounding it. In certain localities it is folded upon itself, constituting the ligamenta alaria and the liga-

mentum mucosum (page 277); in others it is prolonged as bursal pouches, as in relation to the tendon of the popliteus muscle on the back part of the external semilunar cartilage. The synovial membrane extends upward, in front of the shaft of the femur, above the condyles, and receives the insertion of the sub-crureus muscle (page 249), the action of which serves to draw upward the membrane during the movements of the joint. There is a bursa between the tendon of the quadriceps and the femur above the patella, which in the majority of cases communicates directly with the cavity of the joint, so that they are practically one. In *synovitis of the knee* the upward extension of the synovial membrane allows of a considerable swelling *above* the patella, and if there is an excessive amount of fluid within the joint the patella itself is lifted away from the lower end of the femur. There is always more or less fat outside of the synovial membrane, which fills up the interspaces.

Before considering the movements permitted at the knee-joint, the relations of the surrounding tendons should be examined. The ligamentum patellæ is especially strengthened by the lateral attachments of the vasti tendons, and on the outer side by the ilio-tibial band of the fascia lata (page 245). Internally are the tendons of the sartorius, gracilis, and semi-tendinosus, and posteriorly the tendons of the gastrocnemius, plantaris, and semi-membranosus, as well as the tendons of the biceps and popliteus. The relation of the latter tendon is important, as it arises within the joint, and is the weakest part, allowing of a communication between the popliteal space and the cavity of the joint by which pus or fluid may find ingress or egress from one to the other. Regarding the ligaments it may be said, in a general way, that when the joint is extended they are all rendered tense, to prevent over-extension and thus economize muscular force, whereas when the joint is flexed they are all relaxed, so that they allow the tibia to rotate slightly. The crucial ligaments are the strongest, and are more or less tense in all positions of the knee, while the lateral ligaments are comparatively weak, being tense when the joint is extended and relaxed when it is flexed. They are lax enough to admit of partial dislocation of the head of the tibia without rupture.

In studying the complicated motions of the knee, they should be examined as occurring between the patella and the condyles of the femur (already described, page 272), and between the condyles of the femur and the head of the tibia with its articular surfaces deepened by the semilunar cartilages. The latter consist chiefly in flexion and extension, with a slight rotation inward or outward of the tibia in certain positions. The movements of flexion and extension are modified by a certain amount of gliding of the bony surfaces upon one another, so that the same parts are not always in contact, owing to the axis of motion not being fixed. In extreme flexion the back part of the condyles of the femur rests upon the back part of the articular surfaces of the tibia; but if the leg is gradually brought forward the tibia slides forward upon the condyles until the fully-extended position is reached, when the front part of the condyles rests upon the front part of the articular surfaces, the axis of motion steadily shifting forward. Just before extension is completed it will be noticed that the effort is accompanied by a slight *outward* rotation of the leg, which is due to the greater length of the internal condyle (page 241), to the inclination outward of the front part of the corresponding articular surface, and to the mode of attachment of the posterior crucial ligament. In bending the limb from the extended position the reverse of these movements takes place, flexion being checked during life only by the contact of the leg with the thigh. While the limb is in the semi-flexed position and the ligaments are relaxed, the tibia can be independently rotated on the femur, rotation inward being effected by the conjoint action of the popliteus, semi-tendinosus, and semi-membranosus muscles, and rotation outward by the action of the biceps muscle (page 263). Extension of the leg on the thigh is produced by the quadriceps extensor muscle acting through the leverage afforded by the patella, while flexion is produced by the hamstring muscles assisted by the sartorius and gracilis. In flexion and extension the semilunar cartilages move with the tibia, while in the movements of rotation the cartilages are fixed and the tibia rotates independently *beneath* them. Owing to this arrangement, one or other of the cartilages may be *dislocated* and become locked between

the tibia and the femur. The accident usually follows from a sudden twist given to the leg when the knee is bent, as in dancing, and having once happened is liable to recur.

The value of understanding the surface-anatomy of the knee cannot be overstated, and every surgeon should cultivate an artistic sense of the proportion and changes of contour in this joint, not only in the recumbent position usually assumed when the parts are affected through injury or disease, but also in the erect position, when the body-weight is transmitted to the leg, both while at rest and in the attitudes and postures unconsciously assumed in walking, running, and leaping. A knowledge of the construction of the joint may serve to interpret many symptoms and to explain the production of various movements, but what has been aptly called the "language of form" appeals to the judgment, and, if properly applied, often determines the diagnosis and the result of treatment.

The bony prominences about the knee are so superficial that they may be generally referred to with precision as *landmarks.* Of these the patella and the condyles of the femur are easily distinguishable above the joint, and the tubercle, outer tuberosity, and inner border of the head of the tibia, as well as the styloid process of the fibula, below it. The *skin* over the front of the knee is very movable, and in relation to the patella and tibial tubercle is especially dense, owing to the thickening of the epidermis. At the sides and over the popliteal space the skin is much thinner, and is attached by radiating fibres to the inner and back part of the head of the tibia and to the head of the fibula. The mobility of the skin over the anterior part of the joint affords considerable protection, as is noticeable in cuts or contusions, where the violence is thus directed away from the underlying articulation. In extreme flexion the integument is so tightly drawn over the patella that a fall directly upon the knee-cap often results in a lesion like an incised wound. Such an injury, involving both knees, occurred in a hospital patient under the author's care several years ago. In amputation at the knee the anterior flap is composed chiefly of the skin and the small amount of fat in the subcutaneous tissue (Plate 95, Fig. 3).

In examining the knee through the surface-tissues in front the patella can be both felt and seen, its inner border being always more marked than its outer. When the lower limb is extended, so that the leg is supported by the contraction of the quadriceps muscle, its tendon, the patella, and the patellar ligament are in prominent relief, the patella itself being rigidly immovable against the lower end of the femur; but if in the same position the leg is supported so that the quadriceps is relaxed, the patella can be readily moved from side to side. In flexion, the patella glides into the hollow of the intercondyloid notch and is firmly fixed, so that in kneeling it receives the brunt of the weight. While the knee is bent it is usually possible to detect the anterior part of the trochlear surface of the femur. On the outer side of the joint the external condyle of the femur and the corresponding tubercle of the tibia can be felt through the skin, and when the joint is slightly flexed the tendon of the biceps muscle forms a rigid cord passing to the head of the fibula. In front of this tendon is the long external lateral ligament, and between it and the patella is the ilio-tibial band of the fascia lata passing to its attachment on the external tibial tuberosity. The latter is rendered most conspicuous when the body is supported upon one leg. The head of the fibula is nearly on the same level as the tubercle of the tibia, a fact which is often of service in taking measurements of the leg for the lines of the arteries. On the inner side the internal condyle of the femur forms the rounded eminence which gives the characteristic shape to this part of the knee. It is much more conspicuous than the outer condyle. Above it is the adductor tubercle for the tendon of the adductor magnus muscle, which can be felt by deep pressure, and below is the internal tuberosity of the tibia. When the joint is moved it is possible to detect the line of the articulation between the internal condyle and the internal tuberosity, a fact which is especially useful in the consideration of knee-joint amputation (page 294).

Upon removal of the skin and the outer layer of superficial fascia over the front and sides of the knee, the *superficial vessels and nerves* are exposed (Plate 90, Fig. 1, and Plate 91, Fig. 1). The *superficial arteries* of this region are branches of the anastomotica magna (page 256),

the external and internal articular from the popliteal artery (page 288), and the anterior tibial recurrent (page 307). Their positions should be carefully noted, so that they may be avoided in the incisions for the relief of the various abscesses which occur in this region, or in the operation of tapping the joint.

The *patellar arterial rete* consists of twigs from the above sources, which surround the patella as follows. Upon the outer side above the knee the superficial branch of the superior external articular artery issues from the intermuscular septum between the biceps and the vastus externus, and, joining with the terminal twig from the external circumflex artery (page 260), penetrates the fascia lata and anastomoses across the upper border of the patella with the twigs from the superficial branches of the anastomotica and superior internal articular arteries upon the inner side. These unite between the tendons of the adductor magnus and vastus internus muscles, and become superficial at the upper and inner border of the patella. Upon the outer side below the knee the superficial branch of the inferior external articular artery joins with the recurrent branch from the anterior tibial beneath the tendon of the biceps near its insertion, and then, penetrating the deep fascia, sends branches both under and over the ligamentum patellæ, which unite with the superficial branch of the inferior internal articular artery after it issues in front of the internal lateral ligament. The lateral communicating arteries between the upper and the lower arteries of the patellar rete pass two and a half centimetres, or about an inch, below the external and internal borders of the patella respectively. The vessels which furnish this abundant superficial blood-supply also send branches (notably the anastomotica and superior articular) to the deeper structures of the articulation; and therefore the application of blisters and different forms of counter-irritation to the front of the knee is a rational means of relieving intra-articular inflammation, as by their action an increased flow of blood is induced into the superficial branches, thereby diminishing the amount of blood in the deeper branches. The *superficial veins* also form a rete about the patella. They terminate in trunks which empty into the *internal saphenous vein*, or one of its contiguous

tributaries, generally above the internal condyle of the femur (Plate 86, and Plate 90, Fig. 1). The *superficial lymphatic vessels* are chiefly upon the inner side of the knee, and follow the course of the internal saphenous vein.

The *superficial nerves* on the front of the knee are derived from the external, middle, and internal cutaneous nerves of the thigh. They join with one another, forming the subcutaneous *patellar plexus* of nerves (Plate 90, Fig. 1).

The *bursæ* over the front of the knee are severally described with the other structures of the localities in which they occur. They are the bursa beneath the tendon of the quadriceps extensor muscle (page 279), the pre-patellar bursa (page 271), and the bursa of the ligamentum patellæ (page 274).

The back of the knee, when the joint is flexed, presents a lozenge-shaped hollow called the *ham*, or **popliteal space.** As already stated (page 264), this space is included between the tendon of the biceps muscle upon the outer side and the tendons of the semi-membranosus, semi-tendinosus, and gracilis muscles on the inner, these tendons being specially designated as the hamstrings. They can be felt through the skin. The popliteal space occupies the lower third of the thigh and the upper fifth of the leg, extending from the opening in the tendon of the adductor magnus above to the lower border of the popliteus muscle below. It disappears in the extended position of the limb, and in standing there is always a rounded prominence caused by the backward pressure exerted by the condyles of the femur.

The *skin* here is not so movable as it is in front of the knee. It is delicate, and prone to contraction when incised or destroyed by burns. The flexion-crease in the skin is two centimetres, or about a finger-breadth, above the line of the joint. The *cutaneous nerves* are derived from the lesser sciatic nerve, which descends in the superficial fascia to the calf of the leg, and from the internal cutaneous nerve upon the inner side. The deep fascia is called the *popliteal fascia* (Plate 89, Fig. 1, and Plate 91, Fig. 3). It is a continuation of the fascia lata, and is strengthened by transverse fibres. This fascia blends with the

sheaths of the tendons on the sides of the space, and affords protection to the important vessels and nerves beneath. In extension it is rendered so tense that it is impossible to distinguish any of the deeper parts, but in the position of semi-flexion both the popliteal artery and the peroneal nerve can be felt. Owing to the unyielding character of this fascia, a growth or collection of pus or blood within the space is generally attended with severe pain. To the same cause may be attributed the direction in which a popliteal abscess may extend, upward into the thigh, or downward into the leg, and, rarely, into the knee-joint through the posterior ligament. At the lower part of the space the *short saphenous vein*, or *superficial sural vein* (page 302), penetrates the popliteal fascia to reach the popliteal vein (Plate 91, Fig. 4, No. 8). The contraction exerted upon this vein as it passes through the narrow opening in the fascia in certain occupations where the standing position is long maintained is probably a frequent cause of *varices*, and it has been suggested that such cases may be relieved by enlarging the fascial opening. Upon removal of the fascia, the contents of the space will be exposed embedded in a quantity of fat, which protects them in the flexion of the knee-joint. The structures must be carefully cleared of this fat in order to study their relations (Plate 91, Fig. 4, and Plate 92, Figs. 2 and 3). The boundaries will thus be seen to be formed above by the divergence of the hamstring muscles, already described, and below by the converging heads of the gastrocnemius muscle, with the addition of the plantaris on the outer side. The lower boundaries cannot be satisfactorily felt through the skin. In the middle of the space are the important popliteal vessels and nerves, the nerves being more superficial than the vessels. The popliteal artery lies close upon the floor of the space, being intimately connected with the popliteal vein, which is, however, superficial to it. At the apex of the popliteal space the *great sciatic nerve* (page 265) usually divides into its two great branches, the peroneal (or external popliteal) and the internal popliteal. As previously stated, the point of division may be higher or lower in different bodies, and often varies in the two limbs of the same body.

The peroneal nerve passes close along the inner side of the tendon

PLATE 88.

Deep dissections of the anterior of the thigh. The rectus and vastus internus and crureus muscles on both sides are removed to show the great profunda femoris artery on the right side and the perforating arteries on the left.

1. The right iliacus muscle.
2. The cut end of the tensor vaginæ femoris muscle turned upward.
3. The right sacral plexus of nerves.
4. The superficial circumflex iliac artery.
5. The gluteus medius muscle.
6. The cut anterior crural nerve.
7. The right femoral artery.
8. The right femoral vein.
9. The pectineus muscle.
10. The adductor longus muscle.
11. The cut end of the superficial femoral artery.
12. The profunda femoris artery.
13. The branches of the obturator nerve to the adductor muscles.
14. The anterior surface of the shaft of the right femur.
15. The vastus externus muscle.
16. The adductor magnus muscle.
17. The right gracilis muscle.
18. The right sub-crureus muscle.
19. The cut ends of the femoral vessels, where they pass to and from the popliteal space.
20. The aponeurotic arch.
21. The cutaneous branch of the obturator nerve passing to the inner side of the knee.
22. The anastomotica magna artery.
23. The articular surface of the external condyle of the right femur.
24. The top of the tibia.
25. The left common iliac artery.
26. The left common iliac vein.
27. The trunk of the left internal iliac artery.
28. The anterior superior spinous process of the ilium.
29. The tensor vaginæ femoris muscle.
30. The tendon of the psoas magnus muscle blending with the iliacus.
31. The cut pectineus muscle.
32. The obturator externus muscle.
33. The cut adductor longus muscle.
34. The left obturator nerve.
35. The first perforating artery.
36. The adductor brevis muscle.
37. The anterior surface of the shaft of the left femur.
38. The second perforating artery.
39. The left vastus externus muscle.
40. The third perforating artery.
41. The left gracilis muscle.
42. The left sub-crureus muscle.
43. The cut femoral vessels at the opening in the aponeurotic arch.
44. The anastomotica magna artery.
45. The external condyle of the left femur.
46. The tendons of the gracilis and semi-tendinosus muscles.
47. The ligamentum patellæ.

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[illegible] printed and colored from nature, [illegible] McClellan M.D.

[illegible]

of the biceps muscle (Plate 89, Fig. 2, and Plate 91, Figs. 2, 3, and 4), and then enters the groove between this tendon and the outer head of the gastrocnemius muscle to reach the head of the fibula, whence it divides and continues down the leg as the anterior tibial nerve and the musculo-cutaneous nerve (page 309). The peroneal nerve, within the popliteal space, distributes two external articular nerves which accompany the external articular arteries, a recurrent articular nerve which passes with the recurrent tibial artery to the front of the knee, and several cutaneous branches which descend as far as the middle of the calf of the leg. In relation to the tendon of the biceps the peroneal nerve is covered only by the skin and fasciæ, and can be felt. It is so closely associated with the outer hamstring that in the operation for its division great care should be taken not to injure the nerve.

The (*internal*) **popliteal nerve** is the larger of the two divisions of the great sciatic (page 265). It accompanies the popliteal vessels, being always superficial to them, and at the lower border of the popliteus muscle it continues in the leg as the posterior tibial nerve (page 319). This nerve is a little to the outer side of the popliteal artery, and gives off muscular branches (Plate 92, Fig. 12) to the gastrocnemius, plantaris, soleus, and popliteus muscles, and three articular nerves, two of which accompany the internal articular arteries, and the third passes with the azygos artery through the posterior ligament of the knee. The last branch of the popliteal nerve is called the *short* or *external saphenous nerve*, because it is in close association with the vein of that name (Plate 93, Fig. 1, No. 7). It descends behind the outer malleolus to the side of the foot and little toe (page 303). This nerve is brought into connection with the peroneal nerve by means of the *communicans peronei nerve*, which crosses over the outer head of the gastrocnemius muscle.

The popliteal artery is the continuation of the superficial femoral which, after issuing from the canal of Hunter (page 265), accompanied by its vein, enters the ham obliquely at its upper and inner part, under the semi-membranosus muscle (Plate 90, Fig. 2, No. 4). At first the popliteal artery rests upon the triangular space of the femur above the

intercondyloid notch, then upon the posterior ligament of the knee, and finally upon the popliteus muscle, at the lower border of which it divides into the anterior and posterior tibial arteries (Plate 92, No. 11). It is well to note that the termination of the popliteal artery is about on a level with the tubercle of the tibia. This vessel can be felt pulsating against the femur at its commencement when the deep fascia is relaxed by flexion of the knee. The *branches of the popliteal artery* are the superior external and internal articular arteries, which run transversely outward and inward above the condyles, the superior and inferior muscular arteries, the cutaneous, the azygos articular artery, and the inferior external and internal articular arteries. The last two pass transversely, the internal below the internal tibial tuberosity, and the external just above the head of the fibula.

The *superior external articular artery* passes beneath the tendon of the biceps and divides into a *superficial* branch (page 284) and a *deep*, which supplies the lower part of the femur and the knee-joint, anastomosing by an arching branch across the bone with the deep branch of the anastomotica magna artery. The *superior internal articular artery* divides between the tendons of the adductor magnus and vastus internus muscles into a *superficial* branch (page 284) and a *deep*, which also passes close to the end of the femur and anastomoses with its fellow from the outer side. The *superior muscular arteries* furnish blood to the vastus externus and hamstring muscles, and anastomose with the terminal branches of the profunda femoris artery. The *inferior muscular arteries*, also called *sural arteries*, supply the two heads of the gastrocnemius and the plantaris. They usually arise about opposite the line of the knee-joint. The *cutaneous arteries* arise either from the main trunk of the popliteal or from one of its branches, and supply the skin of the calf of the leg.

The *azygos articular artery* is a single small branch from the popliteal, which penetrates the posterior ligament together with the genicular branch of the obturator nerve and supplies the synovial membrane and intrinsic ligaments of the knee-joint. The *inferior external articular artery* divides into a *superficial* branch (page 284) and a *deep*, which

anastomoses with the recurrent tibial artery. The *inferior internal articular artery* (often double) winds round the head of the tibia, dividing beneath the internal lateral ligament into a *superficial* branch and a *deep*, which furnishes blood to the head of the tibia. The above are the usual order and subdivision of the branches of the popliteal artery, but the order is frequently varied by one or other of the branches arising higher or lower from the trunk. Occasionally the popliteal divides within the ham into the anterior tibial and peroneal arteries, in which case the posterior tibial is wanting or very small.

The popliteal vein is formed by the venæ comites of the anterior and posterior arteries. It is superficial to the artery, crossing it obliquely from the inner to the outer side, and finally continues upward as the femoral vein. It receives as tributaries branches corresponding to the popliteal arteries as well as the sural veins. There are two valves in the popliteal vein at its commencement in the lower part of the popliteal space, and usually a single valve at the opening in the tendon of the adductor magnus muscle. This vein is remarkable for having the strongest walls of any of the veins in the entire body. This is conspicuous when the popliteal vessels are divided in amputation at the knee-joint, when it is difficult to distinguish the artery from the vein except by the more superficial position of the latter. In violent ruptures of the ham the popliteal vein rarely suffers alone, whereas the coats of the artery often give way. It should be noted that the popliteal artery is peculiarly liable to *aneurism.* This has been explained by the *curved* course of the vessel at all times except in extreme extension of the limb, and by the fact that it divides below into two large branches, both of these conditions predisposing to the occurrence of aneurism. Observations upon the cadaver have also demonstrated that rupture of the middle and internal coats of the popliteal artery may be occasioned by either extreme sudden flexion or extreme sudden extension of the knee. It is possible by flexing the leg against the thigh to diminish markedly the pulse at the inner ankle in the posterior tibial artery.

The operation of tying the popliteal artery is usually done for wounds of that vessel. In the middle of the ham it is a difficult and

hazardous undertaking, owing to the depth of the vessel and to the necessity of extensively interfering with surrounding tissues in order to overcome the tension of the lateral boundaries. Above, the artery may be reached by an incision along the outer border of the semi-membranosus muscle when the leg is extended. Upon dividing the fascia lata this muscle must be drawn aside. In doing so, care should be taken not to injure the popliteal nerve, which is here quite superficial. The artery is to the inner side of it, under cover of the vein, with which it is intimately connected. Below, between the heads of the gastrocnemius muscle, the external saphenous vein and the external saphenous nerve are directly in the way of the incision, which should be made by dissection upon a grooved director in order to avoid them. If any of the muscular arteries are met with, they must be tied at once, as they bleed profusely. Upon reaching the popliteal nerve the leg should be flexed, so as to facilitate its separation from the vessels, and the vein detached carefully from the artery before the ligature is passed about that vessel.

There are four or five *lymphatic glands* deeply placed about the popliteal vessels, which receive the deep lymphatic vessels from the leg. Occasionally there is a small lymphatic gland at the point where the external saphenous vein pierces the popliteal fascia.

The *popliteal bursæ* are deserving of particular attention. Upon the *inner* side there is a large bursa interposed between the tendon of the semi-membranosus and the inner head of the gastrocnemius and the internal condyle of the femur. This frequently communicates with the cavity of the knee-joint. It sometimes becomes enormously enlarged. There is a small bursa placed between the semi-membranosus tendon and the internal tuberosity of the tibia, which is very apt to communicate with the larger one. Upon the *outer* side there is an independent bursa between the popliteus tendon and the external lateral ligament, and another is between the popliteus tendon and the external tibial tuberosity, which is formed by a prolongation of the articular synovial membrane (page 291). Between the outer head of the gastrocnemius and the corresponding condyle of the femur a bursa is sometimes found.

Lastly, a bursa always exists between the biceps tendon and the long external lateral ligament, over which the peroneal nerve passes.

The *popliteus muscle* (Plate 92, Fig. 3, No. 22) can be exposed after removal of the contents of the space, the floor of which it partially forms. It arises by a strong tendon from the lower part of the groove on the outer condyle of the femur within the capsule of the knee-joint, and as it passes beneath the external lateral ligament and the tendon of the biceps it gives origin to fleshy fibres which diverge into a triangular muscle. This is attached to the tibia above the soleal line. The tendon of the popliteus muscle is within the popliteal groove when the knee is flexed, but glides over the outer condyle of the femur when the joint is extended. The tendon is invested with the articular synovial membrane in relation to the external semilunar cartilage. It receives upon its under surface a twig from the popliteal nerve, and is supplied by the contiguous muscular artery. The popliteus acts as a flexor and pronator of the leg.

Ankylosis of the knee, due to fibrous contraction, depends chiefly upon the contraction of the deep connecting bands of the posterior ligament with the posterior crucial and lateral ligaments, aided by the fibrous and fatty tissue. Forcible extension and rupture of these contractions often result in serious damage to the contents of the popliteal space.

Disease of the knee-joint is of very common occurrence, owing to the superficial position of the joint and its consequent exposure to the effects of cold or of injury. Acute synovitis is attended with acute pain, in consequence of the sudden pressure upon the many nerves both within and about the joint. The position assumed upon distention of the cavity of the articulation with fluid is invariably that of *semi-flexion*, in which not only is the greatest amount of fluid naturally accommodated, but also the tension upon the nerves is greatly diminished.

Fractures in this region may occur at the lower end of the femur (already described, page 268), at the patella, or at the upper end of the tibia.

Fracture of the patella is in the majority of instances due to mus-

cular violence, and is then simple and transverse across the bone somewhere above the lower portion, which receives the attachment of the patellar ligament. When the injury is due to direct violence applied to the patella, the fracture is often comminuted (stellate). The accident usually happens when the knee is flexed, as in attempting to regain the upright position, when the forcible contraction of the quadriceps muscle is expended upon the bone while it is resting only with its middle or transverse axis upon the condyles of the femur. The cartilages and fibrous structures enveloping the patella generally yield with the bone, and the synovial membrane of the joint is torn. This of necessity happens wherever the separation of the fragments is at all considerable. The great difficulty experienced in the treatment of fractures of the patella consists in overcoming not only the action of the great extensor muscle upon the upper fragment, but also the obstacle afforded to bony union by the intervention between the fragments of the torn tissues, blood, and synovia which are effused. Swelling rapidly ensues upon such an injury, and attempts at setting the fracture are futile until it is reduced or removed. Union by bony matter is among the rarest feats of surgery, despite the great ingenuity which has been devised for its accomplishment. Although much may be said in favor of the modern method of cutting boldly down and wiring the fragments together, the dangers incurred are hardly justifiable in view of the fact that *ligamentous union* has not been found to be incompatible with usefulness of the limb. In fact, there are many recoveries with little after-evidence of the injury beyond the depression over the knee-cap, and the sense of weakness in jumping or upon quick or prolonged movement.

The upper end of the tibia is not often fractured: its fracture, when it does occur, is generally due to direct violence, as from a carriage-wheel passing over this portion of the limb. Either of the tuberosities may be detached from the shaft, or the latter may be broken transversely below them.

Dislocation of the patella may occur either outward or inward, the former being the more common. This dislocation results from muscular action with the limb extended and the foot rested, when, in fact, the

patella is freely movable, as already stated (page 272). It should be observed that normally the greater prominence of the external condyle of the femur counteracts the tendency of the extensor muscle to draw the patella outward. The line of the rectus muscle, the patella, and the ligament of the patella is a straight one, whereas the line of the femur forms an angle of ten degrees inward with the line of the leg (page 240), and, as the patellar line passes to the outer side of this angle, the contraction of the rectus draws the bone to the outer side. In dislocation of the patella the bone sometimes is turned upon its outer edge, which then rests between the condyles.

Dislocations of the knee proper, between the condyles of the femur and the head of the tibia, are very rare, owing to the great width of the articular bony surfaces and the strength of the ligaments and tendons uniting them. When a dislocation happens from before backward, or to one side or the other, the crucial and lateral ligaments are torn, and more or less damage is done to all the neighboring structures. Partial lateral dislocations of the knee sometimes occur without the lateral ligaments being ruptured, as previously stated.

The operation of *excision of the knee-joint* may be done by making a curved incision as for the anterior oval flap of an amputation, or by a straight incision in the median line. When the curved incision is adopted it should not extend too far back over the inner condyle, on account of the position of the internal saphenous vein. After the joint is opened and the lower end of the femur bared, it should be brought forward and the articular surfaces sawed off in a direction perpendicular to the shaft. The epiphyseal line should be carefully observed, so as to preserve its influence upon the growth of the bone. It is indicated upon the surface by the level of the adductor tubercle. After the removal of the articular surfaces of the femoral condyles, the head of the tibia is protruded and its articular surface also sawn above the tibial epiphysis. The latter is irregular, including the tuberosities and the tubercles. It should be remembered that the lower femoral epiphysis joins the shaft about the twentieth year, and that the upper tibial epiphysis becomes united to its shaft between the twenty-first and twenty-

second years. The popliteal vessels are much closer to the tibia than they are to the femur, so that in excising the tibial articular surfaces they are exposed to great danger of being wounded with the saw.

Amputation at the knee-joint is preferably done by the long anterior and short posterior flap method. The relations of the parts as they appear in this operation on the *left* limb are shown in Plate 96, Fig. 1, and on the *right* limb in Plate 95, Fig. 3. The anterior flap is formed chiefly of the skin and fasciæ with the patella, the incision beginning low down and just in front of one condyle and being carried forward through the ligamentum patellæ above the tibial tubercle to a similar point on the opposite condyle. It is very important to begin and finish the incision for the anterior flap in the manner indicated, so as to avoid or lessen the powerful retraction of the soft parts. If such care is not taken, the condyles may be bared to the extent of an inch or more by this retraction. Upon the completion of the posterior flap the relations of the parts will be found as follows. Near the internal condyle are the anastomotica magna artery, the internal superior articular artery, and the internal saphenous vein and internal saphenous nerve. Near the external condyle is the external superior articular artery. The posterior flap contains the severed tendons of the sartorius, gracilis, semi-tendinosus, and semi-membranosus, the two heads of the gastrocnemius, and the tendons of the popliteus, plantaris, and biceps. In it are also found the popliteal artery (so intimately connected with the popliteal vein that the two require to be dissected apart before they can be severally ligated), the sural arteries, the external saphenous vein and external saphenous nerve, and the peroneal, popliteal, and small sciatic nerves.

THE REGION OF THE LEG.

The leg is the part of the lower extremity between the knee and the ankle. The bones of the leg are the tibia and the fibula, which are joined almost immovably together at the upper and lower ends. The *tibia* is the innermost and the strongest, sustaining the entire weight of the body in the erect position, while the fibula is upon the outer side

and is very slender, serving to give attachment to muscles, and contributing by its lower end with that of the tibia to the formation of the ankle-joint. They are nearly parallel, but, as the tibia is bowed slightly forward and the fibula backward, there is a difference in the relative bearing of the planes of their surfaces, so that the fibula occupies a position posterior to that of the tibia. This is most noticeable in the upper three-fourths of the leg, and is a fact which should be remembered in all operations upon this region, especially in the formation of the flaps and the sawing of the bones in amputations. The upper end of the tibia is expanded, and about twice as broad as the lower end. It is particularly described with the region of the knee (page 272). The *shaft of the tibia* is in the greater part of its extent three-sided, so that its cross-section appears triangular (Plate 95, Fig. 4, No. 8). It gradually decreases in size to the commencement of the lower fourth, where the bone is most slender and consequently is most frequently fractured. Below this point it gradually expands again toward its lower extremity at the ankle. The *inner surface* is flat and subcutaneous below the tendinous insertions of the gracilis, semi-tendinosus, and sartorius muscles (page 247). This surface is the largest subcutaneous area of bone in the entire skeleton, being covered, besides its periosteum, only by fascia and skin. It is remarkably free from ridges or depressions, and presents a gently undulating form (Plate 92, Fig. 1). The *anterior border* (the crest, or shin) is easily felt through the skin, being sharp and elevated in the upper three-fourths and curving outward to the external tuberosity. Below, it is not prominent, the anterior surface of the lower fourth of the tibia becoming rounded, and only a slight ridge continuing toward the internal malleolus. It therefore appears slightly sinuous when viewed from in front, and is always conspicuous when the muscles of the leg are poorly developed. As the anterior border is composed entirely of compact tissue, it adds greatly to the strength of the bone. The *outer surface* is slightly hollowed in its upper portion for the accommodation of the attachment of the tibialis anticus muscle, while below it turns forward and becomes broad and supports the tendons of the extensor muscles as they pass to the foot. The *external border* is turned

PLATE 89.

Figure 1.

The fascia lata over the gluteal and femoral regions, with the superficial vessels and nerves, as seen upon the removal of the skin and superficial fascia from the posterior surface of the right hip and thigh. On the left, the deep fascia is removed to display the superficial muscles in these regions.

1. The gluteus maximus muscle.
2. Branches of the small sciatic nerve.
3. The fascia lata.
4. Branches of the first perforating artery.
5. The small sciatic nerve.
6. The vastus externus muscle.
7. The biceps muscle.
8. The femoral artery.
9. The internal popliteal nerve.
10. The femoral vein.
11. The superior external articular artery.
12. The plantaris muscle.
13. The external popliteal nerve.
14. The insertion of the tendon of the biceps muscle.
15. The adductor magnus muscle.
16. The gracilis muscle.
17. The semi-tendinosus muscle.
18. The semi-membranosus muscle.
19. The superior internal articular artery.
20. Branches of the small sciatic nerve.
21. The external saphenous nerve.
22. The external saphenous vein.
23. Branches of the small sciatic nerve.
24. The internal saphenous vein.
25. The fascia lata over the popliteal space.
26. The fascia lata over the gluteus maximus muscle.
27. Branches of the external cutaneous nerve.
28. The fascia lata.
29. Branches of the small sciatic nerve.

Figure 2.

Deeper dissections of the buttocks and thighs, showing the relations of the external rotator muscles of the thigh, the branches of the gluteal and sciatic vessels, and the sciatic nerves; also the hamstring muscles and the relations of the parts in the popliteal space.

1. The gluteus medius muscle.
2. The gluteus maximus muscle reflected.
3. Branches of the left gluteal artery, vein, and nerve.
4. Branches of the left sciatic artery and vein.
5. Bursa over the great trochanter.
6. The great sciatic ligament.
7. The arteria comes nervi ischiatici.
8. The small sciatic nerve, drawn outward.
9. The ischial origin of the biceps muscle, drawn outward.
10. The fascia lata.
11. The external saphenous vein (unusually high in this case).
12. Branches of the middle perforating artery.
13. The great sciatic nerve above its division.
14. The external popliteal nerve.
15. The femoral artery.
16. The femoral vein.
17. The plantaris muscle.
18. The inferior external articular artery.
19. The gastrocnemius muscle.
20. The adductor magnus muscle.
21. The left semi-tendinosus muscle.
22. The gracilis muscle.
23. Branches of the middle perforating artery.
24. The internal popliteal nerve.
25. The left semi-membranosus muscle.
26. The inferior internal articular artery.
27. The external saphenous vein.
28. The right semi-tendinosus muscle.
29. Branches of the middle perforating artery.
30. The anastomotica magna artery.
31. The right semi-membranosus muscle.
32. The internal popliteal nerve.
33. The articular and sural arteries.
34. Branches of the right gluteal artery.
35. The gluteus minimus muscle.
36. The gemelli and obturator internus muscles.
37. The right sciatic artery.
38. The pyriformis muscle.
39. The quadratus femoris muscle.
40. The cut attachment of the gluteus medius muscle.
41. The great sciatic nerve.
42. The cut attachment of the gluteus maximus muscle.
43. The adductor magnus muscle.
44. The vastus externus muscle.
45. The great sciatic nerve.
46. The fascia lata.
47. The biceps muscle.
48. The external popliteal nerve.
49. The popliteal vein.
50. The popliteal artery.
51. The external saphenous nerve.

Fig 1

Fig 2

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toward the fibula, and extends nearly the whole length of the bone. It is very sharp, especially at the middle, and gives attachment to the interosseous membrane. The *posterior surface*, immediately below the insertion of the popliteus muscle (page 291), presents an *oblique line* for the origin of part of the soleus muscle, and hence it is also called the *linea solea.* Lower down the shaft this surface affords attachment to the tibialis posticus and flexor longus digitorum muscles. The *medullary foramen* of the tibia is just below the oblique line, and the canal from it leads obliquely downward. The *internal border* extends from the internal tuberosity to the internal malleolus, and gives attachment from above downward to some of the fibres of the popliteus, soleus, and flexor longus digitorum muscles.

The *lower end of the tibia* gradually expands into a quadrilateral mass, from which a strong process projects on the inner side, constituting the *internal malleolus.* Upon the posterior border of this process there is a groove for the tendon of the tibialis posticus muscle. Inferiorly the lower extremity presents a quadrate articular surface for the astragalus. It is concave from before backward and slightly convex transversely, wider in front than behind. Its anterior edge presents an obtuse ridge which is depressed for the attachment of the capsular ligament of the ankle-joint, and there is frequently a notch into which the neck of the astragalus is received in extreme flexion of the foot. The posterior edge is provided with a similar ridge, which is slightly grooved for the tendon of the flexor longus hallucis muscle. Externally, the articular surface is depressed for the adjacent lower end of the fibula, to which it is connected by the inferior tibio-fibular ligaments. Internally, the internal malleolus descends below the level of the ankle-joint, and is prominently convex and subcutaneous, forming a conspicuous landmark. The internal malleolus descends farther in front than behind.

The *fibula* (*peroneal* or *splint bone*) is very variable in the contour of its surfaces, and is the most slender of all the long bones of the skeleton. Its length about equals that of the tibia, but, as its upper end is articulated with the outer tuberosity of that bone below the level

of the knee-joint, its lower end, forming the external malleolus, projects considerably below the internal malleolus, formed by the lower end of the tibia. The *upper end of the fibula* expands from the shaft into an irregularly quadrate mass, called the *head*, which upon the upper and inner surface is provided with an oblique oval facet for articulation with the corresponding facet on the tibia. A conical eminence, the *styloid process*, projects upward from the outer and back part of the head, and affords attachment to the external lateral ligaments of the knee and the biceps femoris muscle (page 263). This process is an important landmark, as it can always be felt through the skin. It is about on a level with the tubercle of the tibia. The circumference of the head is roughened and gives attachment to the *anterior superior tibio-fibular ligament* and the upper part of the peroneus longus muscle in front, and to the *posterior superior tibio-fibular ligament* and some of the outer fibres of the soleus muscle behind. The *shaft of the fibula* usually presents a rounded external surface throughout its extent, while internally there are three variably-developed ridges between which the bone is flattened or grooved for the origins of muscles. The anterior ridge gives attachment to the anterior tibial fascia, the middle ridge to the interosseous membrane, and the posterior ridge to the septum which separates the peronei muscles from the flexor muscles. The formation of the surfaces and ridges of the fibula renders it peculiarly subject to the action of the muscles to which it gives origin, so that there are often differences in the two fibulæ of the same skeleton. The nutrient foramen of the fibula is usually found at the middle of the posterior surface, and is directed obliquely downward. The lower fourth of the shaft is twisted, causing the *lower end*, or *external malleolus*, to appear directed a little forward at the ankle. The external malleolus presents a slight convex surface or facet internally for articulation with the astragalus, above which is another facet for the lower end of the tibia, the rough bone between the two articular surfaces affording attachment to the inferior tibio-fibular ligaments. At the lower and back part of the external malleolus a deep fossa gives attachment to the posterior portion of the external lateral ligament of the ankle-joint. The summit

of the external malleolus projects downward as far as the level of the joint between the astragalus and the os calcis: it is subcutaneous, and is readily distinguishable through the skin.

The *superior tibio-fibular joint* is an arthrodial or gliding joint. The facets on the two bones are covered in the recent state with cartilage, and are lined with *synovial membrane*, which at its upper and back part sometimes communicates with that of the knee-joint. The *anterior superior tibio-fibular ligament* is composed of strong fibres which pass from the external tibial tuberosity outward to the head of the fibula. The *posterior superior ligament* is behind the joint, under cover of the tendon of the popliteus muscle.

The *interosseous membrane*, or *interosseous ligament*, connects the contiguous borders of the two bones of the leg. It consists chiefly of fibres passing obliquely downward from the tibia to the fibula, which at intervals are reinforced by fibres crossing in the opposite direction. It is broader above than below, corresponding to the shape of the *interosseous space*. In the upper part of the space the membrane is wanting, so that there is an oval opening for the transmission of the anterior tibial artery, three centimetres, or about an inch and a quarter, below the head of the fibula (page 307). In the lower part there is a smaller opening for the anterior peroneal artery, and the membrane is pierced here and there throughout its extent by small vessels.

The lower extremities of the tibia and fibula are connected by the *inferior tibio-fibular joint.* The opposing articular surfaces are roughened, except to a small extent at their lowest parts, where they are smooth and covered with cartilage which is continuous with that of the ankle-joint. This, like the upper joint between these bones, is an arthrodial joint, and its surfaces are covered with a *synovial membrane* which is derived from the ankle-joint below it. The ligaments of the lower joint are especially strong. The *inferior interosseous ligament* is a specialized portion of the general ligament of that name, occupying the interosseous space. It connects the tibia and fibula immediately above the lower articulation. Its fibres are very strong. The *anterior inferior tibio-fibular ligament* is broader below than above, consisting of fibres which

pass obliquely downward and outward. It is partly in contact with the articular surface of the astragalus. The *posterior inferior ligament* is narrower than the anterior, its fibres passing horizontally from the external malleolus to the border of the tibia behind the articulation. The lowest part of the posterior ligament is called the *transverse ligament.* Usually it may be demonstrated as a narrow band stretching across the back of the joint. It projects somewhat below the inferior borders of the bones, and is important on account of its remarkable elasticity.

Although the movements permitted by the articulations between the bones of the leg are very slight, they are of exceeding importance. The fibula is the movable bone. The upper joint enables the head of the fibula to glide just sufficiently to save the slender shaft from the effects of pressure or shocks transmitted from below, and the interosseous membrane subserves the same purpose, although its chief function is to afford attachment to the muscles, separating those in front from those on the back of the leg. The lower joint, through the elastic property of the transverse ligament, allows a slight separation or yielding between the lower ends of the bones in severe strain, and the inferior interosseous ligament acts somewhat like a pad between the bones, as well as a connecting band.

The existence of two distinct bones with a considerable space between them through the entire length of this part of the lower limb produces the breadth characteristic of the human leg, which is in striking contrast to the corresponding part of the limbs of animals.

The *surface-form of the leg* is due chiefly to the tibia, which is so largely subcutaneous, but it is also much influenced by the presence of the fibula, notwithstanding that it is almost wholly covered by the muscles of the region. The anterior border of the tibia, commonly called the *shin,* as well as the internal surface, can be felt from below the knee to the inner ankle. It should be remembered that the shin is curved outward above and inward below, as the natural contour is of great use in determining the nature and condition of a fracture. The head of the fibula can always be distinguished, as already stated, and the lower portion of the shaft of the fibula can be felt down to the outer ankle.

When the tibialis anticus muscle is in action it produces a bulge between the two bones, while a slight furrow is noticeable between it and the adjacent extensor communis digitorum muscle to the outer side. In the upper part of the leg, when these muscles are well developed, this furrow is very marked, and is a guide to the anterior tibial artery (page 307). In the lower part of the leg the muscles become tendinous (Plate 92, Fig. 1), and the tendon of the extensor longus hallucis muscle when in action can be felt in the continuation of this furrow. The muscular mass upon the back of the leg forming the *calf* is peculiar to the erect position, and the superficial parts of the soleus and gastrocnemius muscles are especially distinguishable when the body is raised upon the toes, the difference between the two heads of the latter muscle being thus rendered conspicuous. The inner head always descends lower and is larger than the outer.

The surface-markings depending upon the malleoli and the tendons in relation to them are described with the region of the ankle and the foot (page 337).

The *skin* over the leg is more generally closely connected with the deeper fascia than is the case with that over the thigh. Over the shin and the internal surface of the tibia it is separated from the bone only by the subcutaneous fascia and periosteum, and consequently blows or contusions upon these parts of the leg are associated with much pain and with more or less abrasion of the skin. The hairs on the leg are directed downward and inward, and are larger than those on the thigh, especially on the inner surface.

The superficial veins and cutaneous nerves of the leg are exposed upon removal of the skin (Plate 90, Fig. 1, and Plate 93, Figs. 1 and 4). They are within the layers of fatty and connective tissue which compose the superficial fascia. The *long* or *internal saphenous vein* commences at the inner side of the dorsal venous arch of the foot, and ascends in front of the inner ankle (Plate 90, Fig. 1, No. 7) along the inner side of the leg, in company with the long saphenous nerve, to the knee (page 285). It receives numerous tributaries, both superficial and deep, throughout its course. This vein where it crosses over the inner ankle

offers a safe place for venesection. The *short* or *external saphenous vein* arises from the outer side of the dorsal venous arch of the foot, and, passing behind the outer ankle, ascends along the outer border of the tendo Achillis over the back of the calf of the leg, in company with the external saphenous nerve (Plate 93, Fig. 1, No. 11). It finally pierces the deep fascia (page 286) at the lower part of the popliteal space, to end in the popliteal vein. This vein communicates with the deep veins behind the outer malleolus and receives numerous tributary veins from the back of the leg. Before perforating the popliteal fascia the external saphenous vein usually communicates by one or more large branches with the internal saphenous vein. Owing to the comparatively great length of the superficial veins of the leg and to the large amount of blood which their valves have to support in the vertical position, they are very commonly affected with *varices*. The usual position of the commencement of this condition is at the junction of the deep with the superficial veins, where the blood from the deeper structures is forced by the contraction of the muscles into the superficial veins, which, being outside of the deep fascia, are not influenced by muscular contraction. Undoubtedly varicosed veins of the leg are often due to compression of the iliac veins within the pelvis, which causes a stasis of the blood in their tributaries; and any tight constriction habitually employed, such as that of bands or garters, may produce the same effect upon the internal saphenous vein. The constricting effect upon the external saphenous vein as it penetrates the popliteal fascia has already been referred to (page 286). It should be noted in this connection that the pain complained of by those suffering from varicosed veins of the leg probably depends upon the pressure of the distended saphenous veins upon the sensory nerves by which they are accompanied.

The skin on the back and outer surface of the upper part of the leg is supplied by *cutaneous nerves* derived from the peroneal nerve (page 286). The *musculo-cutaneous branch of the peroneal nerve* pierces the deep fascia about the lower third of the outer side of the leg (Plate 93, Fig. 4, No. 1), and descends over the front of the ankle, where it divides into two branches, which are distributed to the skin of

the foot and toes (page 343). Upon the upper and inner part of the leg the skin is supplied by the *internal cutaneous nerve*, which communicates with the *internal saphenous nerve.* The latter becomes subcutaneous between the tendinous expansions of the sartorius and gracilis muscles on the inner side of the knee, where it comes in close relation with the internal saphenous vein (Plate 90, Fig. 1, No. 5). It descends with the vein, giving off branches on each side all the way to the inner side of the great toe. The *patellar plexus of nerves* is formed by branches of the internal, middle, and external cutaneous nerves, with the patellar branch of the internal saphenous nerve (page 285).

The skin over the calf of the leg is supplied by the *small sciatic nerve* above, and by the *short saphenous nerve* below. The latter is derived from the popliteal nerve (page 287), and passes between the heads of the gastrocnemius muscle to the middle of the back of the leg, where it pierces the deep fascia and continues down the leg in company with the external saphenous vein. On the calf the external saphenous nerve joins the peroneal nerve by the *communicans peronei nerve.*

The *superficial lymphatic vessels* of the leg are very large, and, arising from a plexus on the dorsum of the foot beneath the venous arch, pass upward and inward, mostly over the surface of the tibia, toward the internal saphenous vein, with which they ascend. Upon the back of the leg the lymphatic vessels accompany the external saphenous vein, and occasionally there is *a lymphatic gland* situated over the opening for the vein in the popliteal fascia.

The *deep fascia* of the leg is continuous with the fascia lata above. It forms a firm investment, being especially strong about the knee, where it is attached by its deeper fibres to the heads of the tibia and fibula, and, being connected on the inner side with the tendinous expansions of the sartorius, gracilis, and semi-tendinosus muscles, and upon the outer with the tendon of the biceps and the vastus externus as well as the ilio-tibial band, it is rendered tense when these muscles are in action. In the middle of the leg the deep fascia is attached to the crest of the tibia, and from its under surface expansions pass to the anterior and external borders of the fibula. As in the forearm, the deep fascia

forms sheaths for the structures which it encloses, and affords origin for the outer fibres of the muscles, on account of which its dissection from the muscles in the upper part of the leg is especially difficult. At the back of the leg the deep fascia is not so thick as it is in front, and an expansion from it extends beneath the gastrocnemius and soleus muscles, separating them from the deeper layer of muscles. The septa from the deep fascia between the muscles, both upon the anterior and inner parts of the leg (Plate 92, Fig. 1) and upon the outer part (Plate 91, Fig. 5), are not so distinct that they can be relied upon as guides to the vessels in operating, owing to the intimate association of the muscle-fibres with their sheaths. In the lower part of the leg toward the ankle the deep fascia is reinforced by numerous arching or transverse fibres, forming the strong *annular ligaments* which serve to confine the tendons in this situation. These are described with the ankle (page 345).

The muscles on the front of the leg (Plate 92, Fig. 1) are the tibialis anticus, the extensor longus digitorum, the peroneus tertius, and the extensor proprius or longus hallucis. The *tibialis anticus muscle* arises from the lower part of the outer surface of the head of the tibia and the upper two-thirds of the outer side of the shaft, from the interosseous membrane, from the fascia which covers it, and from the adjoining intermuscular septum. The fibres converge to a strong flat tendon which begins on the front of the muscle about the lower third of the leg (Plate 92, Fig. 1, No. 11) and descends obliquely over the front of the ankle through the innermost compartment of the anterior annular ligament to the inner side of the foot. It expands to be inserted into the internal cuneiform bone and the base of the metatarsal bone of the great toe. The sheath of the tendon is surrounded by a long synovial bursa beneath the anterior annular ligament, which extends to within two and a half centimetres, or about an inch, of its insertion. This muscle is supplied by the anterior tibial nerve. Its action serves to flex the ankle and to evert the foot. When the foot is the fixed point, as in standing, it assists in balancing the body at the ankle.

The *extensor longus digitorum muscle* arises from the outer tuberosity of the tibia, superficially to the tibialis anticus, from the upper three-fourths of the anterior surface of the tibia, from the interosseous membrane, and from the overlying fascia and adjacent intermuscular septa. Its fibres terminate in a penniform manner upon a long tendon which begins on the anterior surface of the muscle and descends in front of the ankle through the outermost compartment of the anterior annular ligament. Here the tendon divides into four slips, which pass over the dorsum of the foot and are inserted into the second and third phalanges of the four outer toes. Each of these tendons expands over the base of the corresponding first or proximal phalanx into an aponeurosis, on the outer side of which it is joined by a tendon of the extensor brevis muscle. The *dorsal aponeurosis* of each toe (page 347) divides into three bands at the articulation between the first and second phalanges; the middle band is inserted into the base of the second phalanx; and the two lateral bands pass on and converge to unite and be inserted into the base of the third or distal phalanx.

The *peroneus tertius muscle* is a specialized portion of the preceding muscle. Its fibres arise from the lower fourth of the anterior surface of the shaft of the fibula and the contiguous part of the interosseous membrane, and from the septum between it and the peroneus brevis muscle. The tendon of the peroneus tertius passes with the other tendons under the anterior annular ligament, and expands to be inserted into the dorsal surface of the base of the metatarsal bone of the little toe (Plate 94, Fig. 7, No. 4). The fleshy portion of this muscle is not separable from the rest of the extensor longus muscle, and it is not always present. Both the extensor longus and the peroneus tertius receive their nerves from the anterior tibial nerve (Plate 93, Fig. 3, No. 9). As the tendons pass beneath the annular ligament they are surrounded with *synovial membrane,* which is prolonged for a short distance along each of them. There is also usually a large bursa between the extensor tendon and the outer part of the astragalus. The extensor longus digitorum, besides extending the toes, extends the ankle-joint. The peroneus tertius extends the foot and raises its outer border. The latter muscle acting

PLATE 90.

Figure 1.

The skin removed from the inner side of the right knee, leg, and foot to show the superficial veins and nerves.

1. The internal cutaneous nerve.
2. The internal saphenous vein.
3. Cutaneous branch of the internal superior articular artery.
4. The patellar branch of the internal saphenous nerve.
5. The internal saphenous nerve below the knee.
6. Fascia over the shaft of the tibia.
7. The internal saphenous nerve at the middle of the leg.
8. The internal calcaneal nerve.
9. The communicating branch of the internal saphenous nerve with the musculo-cutaneous nerve.

Figure 2.

Dissection of the inner side of the right knee with the leg extended.

1. The internal saphenous nerve.
2. The insertion of the tendon of the sartorius muscle.
3. Cutaneous branch of the internal superior articular artery.
4. The popliteal artery and vein.
5. The anastomotica magna artery.
6. The aponeurotic expansion from the adductor magnus muscle.
7. The vastus internus muscle.
8. The internal saphenous nerve.
9. The internal saphenous vein.
10. The gracilis muscle.
11. The sartorius muscle.

Figure 3.

Dissection of the inner side of the right knee with the leg in the position of semi-flexion.

1. The patella.
2. The head of the tibia.
3. The internal condyle of the femur.
4. The ligamentum patellæ.
5. The internal lateral ligament of the knee-joint.
6. The insertion of the tendons of the sartorius, gracilis, and semi-tendinosus muscles.
7. The popliteal artery and vein.
8. The anastomotica magna artery.
9. The vastus internus muscle partially dissected to show its nerves.
10. The aponeurotic sheath (called Hunter's canal).
11. The internal saphenous vein drawn down.
12. The internal saphenous nerve.
13. The sartorius muscle.
14. The gracilis muscle.

Figure 4.

Dissection of the inner side of the right knee with the leg flexed at a right angle.

1. The patella.
2. The articular branches of the anastomotica magna artery.
3. The articular cartilage over the lower end of the femur.
4. The popliteal artery and vein.
5. The internal lateral ligament of the knee-joint.
6. The internal semilunar cartilage of the knee-joint.
7. The head of the tibia.
8. The tendon of the sartorius muscle.
9. The ligamentum patellæ, or anterior ligament of the knee-joint.
10. The popliteal artery at its bifurcation.
11. The internal saphenous nerve below the knee (drawn forward).
12. The shaft of the femur.
13. The femoral artery and vein exposed by opening Hunter's canal.
14. The layer of the aponeurotic sheath drawn upward by a hook.
15. Branch of the internal sural artery.
16. Fascia over the inner head of the gastrocnemius muscle.
17. The sartorius muscle.
18. The gracilis muscle.

Plate 90

Fig 1

Fig 2

II

3

Dissected Photographed and colored from nature by George Mc Clellan, M.D.

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with the tibialis anticus serves to raise the foot, and thus performs an important part in progression.

The *extensor longus hallucis muscle* is partly concealed between the tibialis anticus and the extensor longus digitorum. It arises from the inner border of the fibula and the adjacent interosseous membrane in the middle of the leg. The fibres terminate in a penniform manner on the tendon, which passes beneath the annular ligament, surrounded by a special synovial membrane, and is finally inserted into the base of the second, or ungual, phalanx of the great toe (Plate 92, Fig. 1, No. 10, and Plate 94, Fig. 6, No. 14). It is supplied by the anterior tibial nerve. It serves to extend the great toe, and can be recognized, when in action, both on the dorsum of the foot and at the ankle. The extensor hallucis muscle crosses the anterior tibial vessels and nerve near the flexure of the ankle, so that they are usually at the inner side of its tendon above, and at the outer side below (Plate 92, Fig. 1).

The anterior tibial artery arises from the popliteal artery (page 288), at the lower border of the popliteus muscle, and passes to the front of the leg above the interosseous membrane, three centimetres, or about an inch and a quarter, below the head of the fibula. It then descends close upon the anterior surface of the interosseous membrane, being placed deeply between the tibialis anticus and extensor longus digitorum muscles, which must be carefully separated and drawn aside to expose it (Plate 93, Fig. 3, No. 1), when it will be seen with its *venæ comites* and the anterior tibial nerve. About the junction of the middle with the lower third of the leg the artery becomes more superficial, and, passing along the front of the tibia between the tendons of the tibialis anticus and extensor longus hallucis muscles, is continued beneath the anterior annular ligament over the dorsum of the foot as the dorsalis pedis artery (page 343). The *branches of the anterior tibial artery* are the recurrent tibial, muscular, and malleolar arteries.

The *recurrent tibial artery* arises from the main vessel before it reaches the front of the leg. It ascends behind the popliteus muscle close by the outer side of the head of the tibia, to anastomose with the inferior external articular artery and with the anastomotica magna. This

vessel also supplies the upper part of the peroneus longus muscle by a branch called the *superior fibular.* This artery is important for the part it plays in establishing the collateral circulation after ligation of the femoral artery for popliteal aneurism. There are about twelve muscular arteries given off from either side of the anterior tibial, which pass transversely into the anterior group of muscles (Plate 93, Fig. 3). There is usually a perforating anterior recurrent branch, which passes through the origin of the extensor digitorum muscle, seven and a half centimetres, or about three inches, below the tibial tubercle, which may serve as a guide to the anterior tibial artery in the upper part of its course, while another perforating branch sometimes comes forward between the tendons of the tibialis anticus and extensor hallucis below, and may serve the same purpose.

The *malleolar arteries* are given off above the ankle. The *external* is the larger, and passes beneath the tendons of the extensor longus digitorum and peroneus tertius to the *rete* on the outer ankle, with branches from the external tarsal and peroneal arteries (Plate 93, Fig. 3, No. 14). The internal passes beneath the tendons of the extensor hallucis and tibialis anticus and forms a similar *rete* on the inner ankle with branches from the posterior tibial and internal tarsal arteries. The malleolar arteries supply the ankle-joint and the sheaths of the tendons about it. Just above the origin of the external malleolar artery there is a communicating artery which pierces the interosseous membrane and connects the anterior tibial with the peroneal artery. The anterior tibial artery is accompanied by two deep veins, the *venæ comites,* which are connected by venous links across the artery at frequent intervals and join the popliteal vein. The *anterior tibial nerve,* which is a branch of the peroneal nerve (page 287), is in relation to the artery at first upon its outer or fibular side, then passes in front of it, and beneath the annular ligament is again situated upon the outer side (Plate 93, Fig. 3, No. 15).

The line of reference for the anterior tibial artery may be drawn from the outer tuberosity of the tibia to the middle of the ankle-joint. An incision made parallel to the fibular border of the crest of the tibia, and two centimetres, or about three-quarters of an inch, from it,

will correspond pretty closely to the septum between the tibialis anticus and extensor digitorum muscles. This septum is indistinct, as already stated, and it is a waste of time to look for it when seeking to place a ligature about the artery. In such an operation it is essential that the incision should be long enough (about four inches) to enable the operator to distinguish the sheath of the vessels and the relation of the anterior tibial nerve.

The collateral circulation after ligation of the anterior tibial artery is established by the muscular branches and the anastomoses between its empty branches with the anterior peroneal and posterior tibial arteries, also by the communicating artery which connects the dorsalis pedis artery with the external plantar in the foot.

The anterior tibial nerve is derived, in common with the musculo-cutaneous nerve, from the peroneal nerve. It passes forward and inward through the substance of the peroneus longus muscle and beneath the extensor longus digitorum muscle to the outer side of the anterior tibial artery, which it accompanies, as above described. This nerve gives off a *recurrent articular branch* close to the knee, supplies all the extensor muscles on the front of the leg, and at the ankle gives off the *anterior articular branch* before it passes under the anterior annular ligament. Its distribution on the foot is particularly described on page 343.

The muscles on the outer side of the leg are the peroneus longus and the peroneus brevis (Plate 91, Fig. 5). The *peroneus longus muscle* is the more superficial of the two, and arises from the outer surface of the head of the fibula and the upper portion of the shaft below it to a variable extent, from the overlying deep fascia, and from the adjacent intermuscular septa. Its tendon descends, after receiving the fibres, in a penniform manner, and accompanies the tendon of its fellow-muscle in a common fibrous canal behind the external malleolus (Plate 94, Fig. 7, No. 8), which it grooves, and after passing over the outer side of the os calcis it leaves the tendon of the peroneus brevis and passes through a separate canal on the under surface of the cuboid bone (Plate 94, Fig. 3, No. 13), whence it crosses the sole of the foot obliquely, to be finally inserted into the outer side of the base of the first

metatarsal bone of the great toe, and usually into the internal cuneiform bone. The tendon of this muscle as it passes through the several bony grooves and aponeurotic canals is surrounded by synovial membrane. It is also thickened in relation to the malleolus, as well as where it changes its direction to pass across the sole of the foot, and at the latter point there is generally a sesamoid bone developed in the tendon. It should be noted that the uppermost fibres of the peroneus longus are frequently attached to the external lateral ligament of the knee, which is regarded as the femoral origin of the muscle. It is supplied by the peroneal nerve, which pierces the muscle about three centimetres, or an inch and a quarter, below the styloid process of the fibula.

The *peroneus brevis muscle* arises from the lower two-thirds of the outer surface of the fibular shaft, beneath the peroneus longus. It terminates in a tendon, which passes behind the external malleolus through the same canal with the other muscle, and separates from it at the outside of the os calcis to be inserted at the back of the tarsal end of the metatarsal bone of the little toe (Plate 94, Fig. 7, No. 8). From the insertion there is commonly a slip of the tendon which continues on and, piercing the tendon of the *peroneus tertius,* blends with the dorsal aponeurosis of the little toe. This tendon rarely has any fleshy portion, but it is sometimes designated as the *peroneus quinti digiti muscle.* The peroneus brevis receives its nerve from the musculo-cutaneous nerve.

The action of the peronei muscles raises the outer border of the foot, thereby assisting in throwing the chief part of the weight on the ball of the great toe. They also serve, when acting from the foot, in balancing the body on one leg. Excessive action of these muscles produces the distortion of the foot outward called *talipes valgus* (page 357), when in order to bring the foot into proper position the tendons of the peronei generally require division.

The muscles of the back of the leg are arranged in two layers, which are separated by the transverse aponeurosis (page 304). The superficial layer, constituting the calf of the leg, consists of the gastrocnemius, plantaris, and soleus muscles.

The *gastrocnemius muscle* arises by two strong heads from the area of bone above the outer and inner condyles of the femur. The lateral portions of each head are tendinous, but the parts which arise from the supra-condyloid ridges bordering upon the popliteal space are chiefly composed of muscular fibres. The inner head is larger, longer, and more muscular than the outer, and they both broaden as they descend independently until they terminate below the middle of the leg on the commencement of the tendo Achillis. There is a bursa between the origin of the *inner* head and the back of the femur, which commonly communicates with the knee-joint, and sometimes another bursa is interposed between its inner border and the tendon of the semi-membranosus muscle. At the origin of the *outer* head there is not unfrequently either a sesamoid cartilage or a sesamoid bone. The outer head is in contact with the tendon of the biceps muscle and the peroneal nerve; the inner head, with the tendons of the semi-membranosus and semi-tendinosus muscles. The sural vessels and nerves, which are respectively branches of the popliteal artery and popliteal nerve, enter each head toward the middle of the popliteal space. When the gastrocnemius is divided transversely about its middle and reflected (Plate 92, Fig. 2, No. 7), its deeper surface, as well as the contiguous surface of the soleus muscle, will be seen to be covered with a glistening aponeurosis, and the long, white, narrow tendon of the plantaris muscle will be noticed passing along the inner border of the gastrocnemius tendon.

The *plantaris muscle* is the analogue of a similar muscle which is especially developed in the bear and other plantigrade animals. It is often wanting in man, but when present it arises from the outer supra-condyloid ridge, above and internally to the outer head of the gastrocnemius, and from the capsule of the knee-joint. The fleshy portion of the muscle rarely exceeds five centimetres, or two inches, in length, and terminates in a long, thin tendon which descends from without inward between the gastrocnemius and soleus muscles to the inner side of the tendo Achillis, to be inserted at the inner and back part of the os calcis. It is supplied by a branch of the popliteal nerve.

The *soleus* is a broad, flat muscle, resembling the shape of a sole-fish,

whence it has received its name. It arises by tendinous fibres from the head and upper portion of the posterior surface of the fibula, from the aponeurotic arch over the posterior tibial vessels and nerve, from the oblique line on the tibia below the popliteus muscle, and from a variable extent of the inner border of the shaft of the tibia. The muscular fibres bulge laterally beyond the borders of the gastrocnemius, and are arranged in short oblique fascicles passing to the superficial aponeurotic expansion, which forms below a narrow tendinous layer and blends with the tendon of the gastrocnemius to form with it the tendo Achillis. The soleus receives its blood by branches from both the posterior tibial artery and the peroneal artery. Its nerve is a branch of the popliteal, and enters the upper part of the muscle (Plate 92, Fig. 2, No. 14).

The tendo Achillis is the strongest of all the tendons in the body. It is inserted into the lower and back part of the os calcis, and measures eleven centimetres, or about four and a half inches, in length, two centimetres, or three-fourths of an inch, in breadth, at the narrowest part (four centimetres, or one and a half inches, above the heel), and six millimetres, or one-fourth of an inch, in thickness. The tendon expands somewhat at its insertion, above which it is separated from the upper and back part of the bone by a *synovial bursa,* and both the tendon and the surface of the bone are coated with a thin layer of fibro-cartilage which serves to diminish friction.

The *action* of the muscles of the calf and their common tendon is chiefly to raise the body on the toes. The arrangement of their fibres into short fascicles and their peculiar insertion into the tendinous expansions render the muscles capable of powerful contraction, while the insertion of the tendo Achillis, and the attachments of the two heads of the gastrocnemius muscle, by passing over the ankle and the knee, give that muscle the power of bending one of these joints while it flexes the other, as in walking. If acting from the heel, as in standing, the gastrocnemius assists in maintaining the leg perpendicularly upon the foot, and thus in balancing the body.

It is noteworthy that the *tibial origin of the soleus muscle* is found only in man and in several of the anthropoid apes. It should be re-

membered that the posterior tibial artery can be reached only by reflecting the tibial origin of the soleus, and that the peroneal artery can be reached only by reflecting its fibular origin.

Upon removal of the superficial muscles from the back of the leg, the *transverse expansion of the deep fascia* (page 305) is brought into view, covering over the deeper muscles and the posterior tibial and peroneal vessels, with their accompanying nerves. The connection of this transverse fascial septum of the leg with the popliteal fascia, as well as with the fascia lata of the thigh, and through that with the fascia lining the pelvic cavity, is of great interest, as it affords a route by which pus from an abscess occurring in one of the regions above may burrow as far as the calf of the leg. In a subject brought to the author's anatomical room a gallon and a half of pus was evacuated through an incision made into the middle of the leg, which proved upon dissection to have originated from a fracture of the lower portion of the sacrum. Investigation showed that the fracture was caused by a blow received two months prior to the death of the individual, and that the nature of the injury had not been suspected. At the lower fourth of the leg the transverse fascia increases greatly in strength, is attached to the tibia and the fibula on either side, and toward the ankle forms the *internal* or *deep posterior annular ligament.* This serves to confine the several tendons, as well as the vessels and nerves in their passage to and from the sole of the foot. There is always a quantity of fatty tissue interposed between this deep annular ligament and the more superficial tendo Achillis, so that in the division of the latter for relief in cases of club-foot the important deeper structures are not endangered in the operation.

The deep muscles of the back of the leg are the flexor longus digitorum, the flexor longus hallucis, and the tibialis posticus. The *flexor longus digitorum muscle* arises from the posterior surface of the shaft of the tibia, commencing below the soleal line and extending to within ten centimetres, or four inches, of the ankle, and from the septum between it and the tibialis posticus muscle, the latter extending sometimes across that muscle to the fibula. The fibres terminate on a

tendon which is upon the tibial side of the muscle and descends to pass through a groove behind the inner ankle (Plate 92, Fig. 3, No. 24), where it occupies the second compartment in the posterior annular ligament and is covered by a special synovial sheath (Plate 94, Fig. 5, No. 13). As the tendon of the flexor longus digitorum enters the sole of the foot it receives, under cover of the flexor brevis digitorum muscle (page 349), a slip from the tendon of the flexor longus hallucis, as well as the insertion of the flexor accessorius (Plate 93, Fig. 2, No. 18, and Plate 94, Fig. 5, No. 5), after which it separates into four slips, which pass through the slips in the corresponding tendons of the flexor brevis to be inserted into the bases of the distal or ungual phalanges of the four outer toes. The flexor longus digitorum is supplied by the posterior tibial nerve.

The *flexor longus hallucis muscle* arises from the lower two-thirds of the posterior surface of the shaft of the fibula, from the adjacent interosseous membrane, and from the septum separating it from the peronei muscles, as well as the underlying sheath of the tibialis posticus muscle. It enlarges as it descends, and its fibres are inserted in a penniform manner into its tendon, which grooves the back of the lower extremity of the tibia, the back of the astragalus, and the sustentaculum tali (page 324), and extends along the inner border of the sole of the foot to be inserted into the base of the distal or ungual phalanx of the great toe. The tendon is crossed by the tendon of the flexor longus digitorum, with which it is connected by a slip, as already described. Each of the bony grooves through which the tendon of the longus hallucis passes is converted into an aponeurotic canal by tendinous fibres, and each is lined by synovial membrane. The tendon acts in the line of the axis of the foot, and serves to raise the body on the great toe, being especially concerned in walking and running.

The *tibialis posticus muscle* cannot be well seen without reflecting the former two muscles of the deep layer in this region, as it is for the most part concealed by them (Plate 92, Fig. 4, No. 17). It arises from the upper and back part of the shaft of the tibia, externally to the flexor longus digitorum, from the interosseous membrane, and from the

fibula upon the upper part of its inner surface. Some fibres also arise from the deep transverse fascia and the intermuscular septa which separate it from the adjoining muscles. Its tendon passes beneath that of the flexor longus digitorum and grooves the back of the internal malleolus, and is enclosed in the innermost compartment of the annular ligament, where it is surrounded by synovial membrane. It descends over the internal lateral ligament of the ankle-joint, and upon reaching the sole of the foot is inserted into the lower and back borders of the scaphoid and internal cuneiform bones (Plate 94, Fig. 5, No. 7). In relation to the scaphoid bone the tendon becomes thickened, and usually contains a sesamoid cartilage. From this part offsets pass to the various tarsal and metatarsal bones. The tibialis posticus is supplied by the posterior tibial nerve, and its action is to flex the foot and turn it inward. The tendon of this muscle should be carefully examined as it passes to its insertion, since it frequently requires division for the relief of *talipes varus*, when the tendon acts in conjunction with that of the tibialis anticus (page 305). The tendon of the tibialis posticus can be felt through the skin on strongly inverting the foot, especially if the effort to produce inversion be resisted.

The relative positions of the different structures as they pass beneath the posterior annular ligament are, from within outward, the tendons of the tibialis posticus, the flexor longus digitorum, the posterior tibial artery and its *venæ comites*, the posterior tibial nerve, and the tendon of the flexor longus hallucis (Plate 94, Fig. 5).

The posterior tibial artery arises, in common with the anterior tibial, from the popliteal artery at the lower border of the popliteus muscle. It descends between the superficial and deep layers of the muscles at the back of the leg, and is closely invested with the deep fascia. At the interval between the internal malleolus and the os calcis it curves to enter the sole of the foot, where it divides beneath the abductor hallucis (page 350) into the external and internal plantar arteries (Plate 93, Fig. 2). Throughout its course in the leg it rests upon the tibialis posticus, the flexor longus digitorum, the lower end of the tibia, and the capsule of the ankle-joint.

PLATE 91.

Figure 1.

Superficial dissection of the outer side of the right knee with the leg extended.

1. The fascia lata.
2. The external cutaneous nerve.
3. The tendon of the biceps muscle.
4. The venous plexus about the patella.
5. The semi-membranosus muscle.
6. The popliteal artery and vein.
7. The external popliteal nerve.
8. Superficial branch of the external inferior articular artery.
9. Aponeurosis over the outer portion of the gastrocnemius muscle.

Figure 2.

Deep dissection of the outer side of the right knee with the leg extended.

1. The rectus muscle.
2. The vastus externus muscle.
3. Superficial branch of the external superior articular artery.
4. The insertion of the biceps muscle.
5. The biceps muscle.
6. The popliteal artery and vein.
7. The external popliteal nerve.
8. The fascia over the outer portion of the gastrocnemius muscle.

Figure 3.

Superficial dissection of the popliteal space of the right lower extremity.

1. The fascia over the semi-membranosus muscle.
2. The internal saphenous vein.
3. The tendons of the internal hamstring muscles.
4. The fascia over the inner head of the gastrocnemius muscle.
5. The external saphenous vein where it pierces the aponeurosis of the calf of the leg.
6. The external saphenous nerve.
7. The biceps muscle covered with the deep fascia.
8. Branches of the small sciatic nerve.
9. The fascia over the outer head of the gastrocnemius muscle.
10. Cutaneous branch of the external popliteal nerve.

Figure 4.

Deep dissection of the right popliteal space, showing the branches of the popliteal artery and the relations of the nerves to the tendons.

1. The semi-tendinosus muscle.
2. The semi-membranosus muscle.
3. The popliteal artery and vein.
4. The internal superior articular artery.
5. The internal inferior articular artery.
6. The tendon of the gracilis muscle.
7. The internal sural artery.
8. The external saphenous vein emptying into the popliteal vein.
9. The inner head of the gastrocnemius muscle.
10. The external saphenous vein and nerve.
11. The biceps muscle.
12. The external popliteal nerve.
13. The external superior articular artery.
14. The external inferior articular artery.
15. The external sural artery.
16. The external popliteal nerve in close relation to the tendon of the biceps muscle.
17. The outer head of the gastrocnemius muscle.
18. Cutaneous branches of the external popliteal nerve.

Figure 5.

The muscles on the outer side of the right leg and foot.

1. The semi-membranosus muscle.
2. The external popliteal nerve.
3. The insertion of the biceps muscle.
4. The external popliteal nerve where it pierces the insertion of the peroneus longus muscle.
5. The outer portion of the gastrocnemius muscle.
6. The peroneus longus muscle.
7. The peroneus brevis muscle.
8. The peroneus tertius muscle.
9. The tendo Achillis.
10. The annular ligament.
11. The tendon of the peroneus longus muscle.
12. The tendon of the peroneus brevis muscle.
13. The tendon of the peroneus longus muscle.
14. The extensor brevis digitorum muscle.
15. The tendon of the peroneus brevis muscle.
16. The tendon of the peroneus tertius muscle.
17. The vastus externus muscle.
18. The aponeurotic cap of the knee.
19. The tibialis anticus muscle.
20. The extensor longus digitorum muscle.
21. The extensor proprius hallucis muscle.
22. The tendons seen through the anterior annular ligament.
23. The tendon of the extensor proprius hallucis muscle.
24. The tendons of the extensor longus digitorum muscle.
25. The tendons of the extensor brevis digitorum muscle.

Plate 91

Fig 5

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Dissected Photographed and Colored from Nature by George Mc Clellan, M.D.

The branches of the posterior tibial artery are, besides numerous arteries to the soleus, peronei, and deep muscles, the peroneal artery, the nutrient artery to the tibia, the communicating artery, and the internal calcanean arteries.

The *peroneal artery* is the most important, being frequently as large as the posterior tibial itself. It arises two and a half centimetres, or about an inch, below the bifurcation of the popliteal artery, and passes along the interosseous border of the fibula, and then over the inferior tibio-fibular joint, to the outer part of the os calcis, where it anastomoses with the malleolar and plantar arteries (Plate 92, Fig. 4, No. 9). In its course down the leg it furnishes twigs to the soleus, flexor longus hallucis, tibialis posticus, and peronei muscles, among which it is deeply embedded. It also supplies the *nutrient artery to the fibula,* as well as the *anterior* or *perforating peroneal artery,* which passes through the interosseous membrane to the front of the lower part of the leg and joins in the external malleolar rete (Plate 93, Fig. 3, No. 12). The anterior peroneal artery in some bodies substitutes the anterior tibial artery in the lower part of its course. The peroneal artery has *venæ comites* throughout its course (Plate 92, Fig. 4, No. 6).

The *nutrient artery to the tibia* usually arises from the posterior tibial below the origin of the peroneal. It is the largest artery to the shaft of a bone in the body. It enters the medullary canal two and a half centimetres, or about an inch, below the soleal line, and passes obliquely downward away from the knee-joint. The *communicating artery* passes across the interosseous membrane two and a half centimetres, or about an inch, above the heel, beneath the tendon of the flexor longus hallucis, and anastomoses with the peroneal artery. The *internal calcanean arteries,* of which there are several, ramify over the inner and back part of the os calcis and join the internal malleolar in forming the internal rete. The posterior tibial artery is accompanied by the posterior tibial veins, *venæ comites* (Plate 92, Fig. 4, No. 15), which unite with the veins accompanying the peroneal and anterior tibial arteries and empty into the popliteal vein. The *posterior tibial nerve* is usually at the inner side of the posterior tibial artery above, but it soon crosses to

the outer side, and descends, in close relation to the artery, to the ankle, where it is always at the outer side.

The line of reference for the posterior tibial artery may be drawn from the middle of the lower part of the ham to the middle of the interval between the internal malleolus and the os calcis. *The operation for ligation of the posterior tibial artery* is very difficult in the upper part of the leg, where the artery is deeply situated over the interosseous membrane and covered by the muscles of the calf. An incision four inches in length should be made about two centimetres, or a finger-breadth, along the posterior border of the tibia, care being taken to avoid the long saphenous vein. If the foot is extended and the knee flexed, the tension will be removed from the deep fascia as well as from the calf muscles, and the operator will be enabled to work with less embarrassment. There is generally a quantity of cellular tissue between the soleus muscle and the deep transverse fascia. The latter must be slit upon a grooved director, and the artery will be found in the expansion of the tibial fascia which ensheathes it (page 313), upon the tibialis posticus muscle, about the middle of the limb. Much of the difficulty in reaching this vessel after making the first incision is due to then changing the position of the leg, which should not be done, and it is very important to remember not to divide the soleus muscle too close to the tibia, or the operator will be apt to detach the flexor longus digitorum muscle and get into the substance of the tibialis posticus muscle beneath the vessel. In the ligation of no other artery is the line of reference so strictly to be adhered to as in the case of the upper part of the posterior tibial. The posterior tibial nerve is usually found directly over the sheath of the vessel, above the middle of the leg. In the lower third of its course the posterior tibial artery is more accessible. It may be reached by an incision midway between the tendo Achillis and the posterior border of the tibia, and it will be found, covered by two layers of the deep fascia, at the outer side of the tendons of the tibialis posticus and flexor longus digitorum, with the nerve external to it. *At the ankle* the incision should be *curved* over the course of the artery, midway between the internal malleolus and the point of the heel. Its exposure in this situation

is not always easy of accomplishment, notwithstanding that the vessel can readily be felt pulsating here through the surface-tissues. It is embedded in a quantity of fat, and with its *venæ comites* is included in a sheath of interlacing fibres from the internal annular ligament (page 345). The nerve is very close to the outer side of the vessels, and before attempting to pass a ligature about the artery the foot should be alternately extended and flexed, so as to render the nerve clearly distinguishable. After the incision through the integument, the operator should remember to seek for the vessel nearer to the bone than to the tendo Achillis.

The collateral circulation after ligation of the posterior tibial artery below the origin of the peroneal branch is carried on by the many muscular branches, and especially by the communicating artery between it and the peroneal artery and its connections with the malleolar rete.

The posterior tibial nerve is the continuation of the popliteal nerve. It descends in close relation to the corresponding artery, being at first either superficial to it or at its inner side; but lower down the nerve always crosses to the outer side, as already described (page 315), and is at the inner border of the tendo Achillis (Plate 92, Fig. 4, No. 18). The first branch of this nerve is to the popliteus muscle, which is large, and from it are given off branches to the medullary canal of the tibia and to the interosseous membrane. The latter is peculiar for the occasional development of a pseudo-ganglion below the middle of the leg. The posterior tibial nerve also supplies the tibialis posticus, soleus, flexor longus digitorum, and flexor longus hallucis muscles, as well as the periosteum of the fibula. At the ankle several *cutaneous branches* are given off, which pierce the annular ligament and supply the skin over the heel and the adjacent part of the sole of the foot. The nerve divides into the external and internal plantar nerves, externally to the artery (Plate 93, Fig. 2, No. 1).

In fractures of the leg usually both bones are broken together; but if one or the other is broken separately it is more frequently the slender fibula which is fractured, rather than the larger and stronger tibia. The *fibula* is so well protected by the muscles which it supports that, notwithstanding the position of its long and slender shaft upon the outer

side of the leg, where it is naturally more exposed to injury, it is very rarely broken unless by direct violence. When the fibula is broken in the lower fourth by indirect violence the fracture may be due to either forcible inversion or eversion of the foot, but most commonly is due to *eversion,* unless the external lateral ligament of the ankle-joint is simultaneously ruptured, in which case there is produced an outward dislocation known as *Pott's fracture,* which is particularly described on page 360. That a fracture of the lower third of the shaft of the fibula alone without any dislocation at the ankle is possible, however, was demonstrated to the author by a singular coïncidence, for while actually putting these words on paper he was summoned to a patient who had sustained such an injury from a severe wrench to the right foot, which was probably everted in regaining his equilibrium from a slip on the ice. In fractures of the fibula alone, the unbroken tibia generally affords sufficient splintage to the fragments.

With regard to the tibia, transverse sections of its shaft show that it measures below the tuberosities four and a half centimetres, or one and three-fourths inches, and at the lower end, above the internal malleolus, a little less,—three and three-fourths centimetres, or about one and a half inches,—while at the narrowest part, the junction of the lower with the middle third of the shaft, it measures two and a half centimetres, or about an inch. The latter point is the most common seat of fracture of the tibia from indirect violence; but any part of the bone may be broken by direct violence. Fractures of the tibia are often *comminuted,* and very frequently also *compound,* owing to the great extent of surface which the shaft of the bone presents with only the slight covering afforded by the skin and subcutaneous fascia. In fracture from indirect violence the breach in the bone is usually oblique, and extends downward from behind forward and to a slight degree inward. The fibula is usually broken at the same time, but at a higher level than the tibia. The foot, being as it were semi-detached, is drawn upward by the contraction of the muscles of the calf, so that the lower fragments of the tibia and fibula pass behind the upper fragments. At the same time, owing to the obliquity of the fractured line, the foot

and the lower part of the leg are turned outward. The eversion is also often increased by the weight of the foot. If the line of fracture is transverse there may be little or no deviation from the normal position.

In amputation through the middle of the leg, by antero-posterior flaps, the relations of the severed parts as they appear upon the *right* limb are as follows (Plate 95, Fig. 4). In the anterior flap are the skin and fascia in close relation to the inner surface of the sawn end of the tibia, and covering the cut upper parts of the tibialis anticus and extensor communis digitorum muscles, as well as the upper parts of the peroneus longus and peroneus brevis muscles; the anterior tibial vessels and nerve are between the bones (No. 3), and the musculo-cutaneous nerve is upon the outer side and the internal saphenous vein upon the inner side of the anterior flap. In the posterior flap are the skin, the gastrocnemius, plantaris, soleus, tibialis posticus, and flexor longus digitorum muscles, the posterior tibial vessels and nerves (No. 10), and the peroneal vessels (No. 6). About the middle of the margin of the posterior flap are the external saphenous vein and the external saphenous nerve (No. 7).

The development of both the tibia and the fibula, like that of the radius and the ulna in the forearm, occurs from three centres of ossification. The shaft of the *tibia* first shows a centre in its upper part about the eighth week of fœtal life, the centre for the upper epiphysis appearing about the second week after birth, and the centre for the lower epiphysis at the second year. The latter unites with the shaft in the eighteenth year, while the former does not become consolidated before the twenty-first year. The shaft of the fibula begins to ossify also about the eighth week of fœtal life. The centre for the upper epiphysis begins about the fourth year, the centre for the lower epiphysis earlier, during the second year. The lower epiphysis of the fibula is first attached to the shaft about the twentieth year, and the upper not until the twenty-third year. The fibula should be noted as presenting an exception to the rule that the epiphysis which ossifies first joins the shaft last, probably because of the rudimentary nature of the head of the bone.

THE REGION OF THE ANKLE AND THE FOOT.

The skeleton of the foot consists of the *tarsus*, the posterior portion, the *metatarsus*, the median portion, and the *phalanges*, or the digital extremities. In general arrangement the bones which compose these different portions of the foot correspond to those of the hand, but they are specially modified so as to adapt them to firmness and strength, rather than to mobility.

The tarsus is greater in length than the metatarsus, while the metatarsus is longer than the phalanges, which is the reverse of the relative proportions of their analogues in the hand.

The plantar surface of the foot is after birth always normally turned downward, and the dorsal surface upward, the foot being consequently in a permanent condition of pronation and over-extension.

There are seven *tarsal bones*, each of which is short and thick and composed of cancellous tissue enclosed in a compact layer. They are arranged in three groups, the posterior or basal, consisting of the astragalus and the os calcis, the central, of the scaphoid, and the anterior or distal, of the cuboid and the three cuneiform bones. The dorsal surfaces of the tarsal bones are comparatively smoother than the plantar surfaces, which present projections for the attachment of the ligaments and are grooved for the play of the flexor tendons, while the lateral borders, which are in contact with one another in the recent state, are covered with articular cartilage. The contiguous surfaces of the tarsal bones form gliding joints with one another, but the degree of motion between any two of the anterior group of bones is even less than that between the corresponding carpal bones (page 397, Vol. I.). There is, however, a considerable degree of rotation, as well as of abduction and adduction, between the astragalus and the os calcis and the scaphoid, which should not be overlooked in examining the ankle-joint above, as the motion of the former is sometimes erroneously attributed to the latter.

The *astragalus* is the uppermost bone of the tarsus, and the only one which comes in direct contact with the bones of the leg. Generally

speaking, this bone consists of a body, which projects posteriorly, and a convex portion, the head, which projects anteriorly. The latter presents an elongated ovoid convex surface, which in the recent state is provided with cartilage and articulates with the scaphoid bone. The upper or *trochlear* surface is quadrate in form, slightly concave from side to side, and decidedly convex from before backward. It is also narrower in front than it is behind. It is received into the intermalleolar notch formed by the lower ends of the leg-bones, and its plane is horizontal when in position against the tibia. The under surface presents two facets, separated by a deep groove which extends forward and outward and is broader and deeper in front than it is behind. This groove forms a canal, the *sinus tarsi,* with a similar groove upon the upper surface of the os calcis, and is occupied in the recent state by the *calcaneo-astragaloid ligament.* The anterior facet is often divided by a ridge, so that its front portion rests upon the calcaneo-astragaloid ligament and its back portion articulates with the lesser process of the os calcis, or sustentaculum tali. The posterior facet is much larger than the anterior, and is deeply concave, articulating accurately with the external facet on the os calcis. From the under surface a *posterior process* is elongated, which is variably grooved for the tendon of the flexor longus hallucis muscle. The outer part of this process is called the *external tubercle,* and occasionally it is a separate little bone, the *os trigonum.* It is important, as it limits the degree of flexion at the ankle-joint. Laterally the astragalus is marked by an ear-shaped facet for the internal malleolus, and by a triangular facet which is concave from above downward for the external malleolus. It should be noted that when the foot is extended the anterior part of the trochlear surface and margins of the head of the astragalus can be detected through the skin.

The *os calcis,* or *calcaneum,* is the largest and strongest of the tarsal bones, and is placed below the astragalus, with its long axis directed forward and outward. It projects backward to a variable extent in different individuals, forming the heel. This projection is called the *tuber calcanei:* its posterior surface is smooth above and covered by a bursa, while below it is rough and vertically ridged for the attach-

ment of the tendo Achillis. The *upper surface* of the bone between the point of the heel and the external tubercle of the astragalus is convex from side to side and concave from before backward, corresponding to the fatty tissue which intervenes between the tendo Achillis and the back of the ankle-joint in the recent state. Anterior to this are the facets for articulation with the astragalus, which are two or three in number according to the condition of the opposing surfaces, and are separated by a groove similar to that upon the astragalus in which, as already stated, the interosseous ligaments are lodged. The outer articular surface is larger than the inner one, which is sometimes subdivided into two parts. The inner articular surface is supported on a process which projects inwardly and is known as the *lesser process* of the calcaneum, or the *sustentaculum tali.* The anterior portion of the bone is called the *greater process.* It presents a facet in front for articulation with the cuboid bone, and upon its upper surface there is a rough depression for the origin of the extensor brevis digitorum muscle and the attachment of many ligaments. The *lower surface* of the os calcis is narrow, convex from side to side, and presents posteriorly a small *outer tubercle* and a large, broad *inner tubercle,* which forms the support of the heel (Plate 94, Fig. 1, No. 6). The *external surface* is broad, flat, and subcutaneous. A slight tubercle marks the bone opposite the tip of the external malleolus and affords attachment for the middle portion of the external lateral ligament. A variably-developed peroneal ridge in front of this tubercle separates the tendon of the peroneus brevis above from the tendon of the peroneus longus below. The *internal surface* presents a deep concavity directed obliquely forward and downward for the lodgement of the plantar vessels and nerves and flexor tendons in their passage to the sole of the foot. From this surface the *lesser process* projects inwardly and supports the anterior articular surface of the astragalus, as already described.

The *scaphoid bone* (or *navicular bone*) is situated in front of the astragalus, with which it articulates by a concave oval surface. Anteriorly, the bone is oblong, convex from side to side, and subdivided by two ridges into three facets for articulation with the three cuneiform

bones. The upper, lower, and external surfaces are roughened for the attachment of ligaments. Upon the *inner surface* there is a rounded eminence, the *tuberosity of the scaphoid*, which is an important landmark, as it can always be felt.

The *cuboid bone* is in front of the os calcis, upon the outer side of the foot. Upon its anterior surface there is a vertical ridge separating the facets for the metacarpal bones of the fourth and fifth toes, the inner facet being quadrilateral in form, and the outer one being larger and triangular. The inner surface presents a facet for the external cuneiform bone. The outer surface is comparatively short, and is deeply notched at the commencement of the *peroneal groove*, which extends obliquely forward and inward on the plantar surface of the bone and lodges the tendon of the peroneus longus muscle (page 310). Behind the groove is the *cuboid tuberosity*, for the attachment of the calcaneo-cuboid ligament. Toward the centre of the plantar surface of the foot there is a *posterior process* of the cuboid bone, which is overlapped by a depression on the corresponding surface of the os calcis, and is noteworthy because it impinges upon the *line of Chopart*, which extends across the astragalo-scaphoid and calcaneo-cuboid joints and is sometimes used for amputation in this region (Plate 96, Fig. 4).

Of the three *cuneiform bones* the *internal* is the largest. It articulates by a concave, triangular surface posteriorly with the inner facet on the front of the scaphoid bone, and by a kidney-shaped surface anteriorly with the metatarsal bone of the great toe. Internally it is broad, subcutaneous, and grooved for the tendon of the tibialis anticus muscle (page 305), while the plantar surface is rough for the attachment of ligaments and the insertion of the tendon of the tibialis posticus (page 315). Externally it presents upon its upper and its lower borders an L-shaped articular surface for the middle cuneiform bone behind and the second metatarsal bone in front.

The *middle cuneiform bone* is the smallest not only of the cuneiform bones, but also of the entire tarsus. Its posterior surface is broader than its anterior, and therefore it is more distinctly wedge-shaped than its fellows. It articulates posteriorly with the middle facet on the front of

PLATE 92.

Figure 1.

The muscles on the front of the left leg, and the relations of the anterior tibial artery at the ankle.

1. The aponeurotic knee-cap.
2. The inner portion of the gastrocnemius muscle.
3. The shaft of the tibia.
4. The tendon of the tibialis anticus muscle.
5. The anterior tibial artery.
6. The anterior tibial nerve.
7. The anterior annular ligament.
8. The anterior tibial nerve over the instep.
9. The dorsalis pedis artery.
10. The tendon of the extensor proprius hallucis muscle.
11. The tibialis anticus muscle.
12. The peroneus longus muscle.
13. The extensor longus digitorum muscle.
14. The extensor proprius hallucis muscle.
15. The tendons of the extensor longus digitorum muscle.
16. The external malleolus.
17. The tendon of the peroneus tertius muscle.
18. The extensor brevis digitorum muscle.

Figure 2.

The upper portion of the gastrocnemius muscle removed to expose the soleus muscle and the long tendon of the plantaris muscle of the right leg; also the branches of the internal popliteal nerve.

1. The popliteal artery.
2. The cut inner head of the gastrocnemius muscle.
3. The tendons of the inner hamstring muscles.
4. The popliteus muscle.
5. The tendon of the plantaris muscle.
6. The soleus muscle.
7. The lower portion of the gastrocnemius muscle.
8. Branches of the posterior tibial nerve.
9. The attachment of the tendon of the plantaris muscle to the os calcis.
10. The popliteal vein.
11. The internal popliteal nerve.
12. The external popliteal or peroneal nerve.
13. The cut outer head of the gastrocnemius muscle.
14. The nerve to the soleus muscle.
15. The tendo Achillis.
16. The communicans fibularis nerve.

Figure 3.

Dissection of the back of the left leg and the popliteal space.

1. The tendon of the biceps muscle.
2. The superior internal articular artery.
3. The external popliteal nerve.
4. The internal popliteal nerve.
5. The inferior external articular artery.
6. The head of the fibula.
7. The shaft of the fibula.
8. The peroneal artery and its venæ comites.
9. The nerve to the peroneus longus muscle.
10. The peroneus longus muscle.
11. The tendon of the peroneus longus muscle.
12. The tendon of the peroneus brevis muscle.
13. The tendon of the flexor longus hallucis muscle.
14. The cut tendo Achillis.
15. The posterior tibial nerve.
16. The popliteal artery and vein.
17. The semi-membranosus muscle.
18. The semi-tendinosus muscle.
19. The nerve to the tibialis posticus muscle.
20. The cut inner head of the gastrocnemius muscle.
21. The nerve to the popliteus muscle.
22. The popliteus muscle.
23. The nerve to the flexor longus digitorum muscle.
24. The flexor longus digitorum muscle.
25. The posterior tibial nerve.
26. The posterior tibial artery and its venæ comites.
27. The flexor longus hallucis muscle.
28. The tendon of the tibialis anticus muscle.
29. The tendon of the tibialis posticus muscle.
30. The posterior tibial nerve and vessels.

Figure 4.

Deep dissection of the back of the left leg, to show especially the tibialis posticus muscle and the peroneal vessels.

1. The external popliteal nerve.
2. The popliteal vein.
3. The internal popliteal nerve.
4. The tendon of the biceps muscle.
5. The peroneus longus muscle.
6. The peroneal artery and its venæ comites.
7. The shaft of the fibula.
8. The flexor longus hallucis muscle reflected.
9. The posterior peroneal artery.
10. The tendon of the peroneus longus muscle.
11. The popliteal artery.
12. The tendon of the semi-tendinosus muscle.
13. The cut inner head of the gastrocnemius muscle.
14. The popliteus muscle.
15. The posterior tibial artery and its venæ comites.
16. The shaft of the tibia.
17. The tibialis posticus muscle.
18. The posterior tibial nerve and vessels.
19. The cut tendon of the flexor longus digitorum muscle.
20. The cut tendon of the flexor longus hallucis muscle.
21. The cut tendo Achillis.

Plate 92

Fig 1

Fig 2

Fig 3

15

7

8

Fig 4

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the scaphoid bone, and anteriorly it presents a triangular facet for the head of the second metatarsal bone. Laterally it articulates with the internal and *external* cuneiform bones. The latter articulates posteriorly with the outer facet on the front of the scaphoid bone, and anteriorly with the third or middle metatarsal bone. The lines of these articulations are oblique with the axis of the foot, the posterior line forming an acute angle with the outer side of the bone, and the anterior line forming an acute angle with the inner side of the bone. Upon the outer and inner surfaces it articulates respectively with the cuboid and middle cuneiform bones. It also presents upon the distal border of the outer surface a small facet for the inner side of the base of the fourth metatarsal bone, and a similar facet, but larger, upon the inner surface, for the outer side of the base of the second metatarsal bone. These features are of special importance with reference to the proper comprehension of the character of the tarso-metatarsal joint, which is explained on page 338.

When the entire skeleton of the foot is examined, it will be seen that the narrowest part is formed by the projection of the os calcis, or heel, that it widens at the heads of the metatarsal bones, and that the arrangement of the bones between these points produces an *antero-posterior* or *longitudinal arch.* The piers or buttresses of this arch are formed by the tubercles of the os calcis behind and the distal end of the metatarsal bone of the great toe in front upon the inner side, while the tuberosity of the metatarsal bone of the little toe constitutes an additional but weaker pier in front upon the outer side. The highest point of the longitudinal arch in front of the ankle is called the *instep.* It corresponds to the joint between the astragalus and the scaphoid bone: it is, moreover, the weakest part of the arch, being provided upon the plantar surface with the inferior calcaneo-scaphoid ligament, which, being composed chiefly of elastic fibres, allows the arch to yield slightly, so that it serves not only to enable the foot to withstand the effect of shocks received upon its anterior surface, but also to contribute to the springy action of the foot, so essential in active exercise. The weight of the body is chiefly received upon the arch extending between the heel and the ball of the great toe, and the foot has therefore been con-

sidered to consist of an inner or essential portion, composed of the astragalus, the scaphoid, the three cuneiform bones, and the inner three metatarsal bones with their corresponding phalanges, while the outer or accessory portion is composed of the os calcis, the cuboid, and the bones of the two outer toes. Besides the longitudinal arch, the plantar surface of the foot presents a *transverse half-arch*, which is especially recognizable in the mid-tarsal portion beneath the instep.

When the imprint of a wet foot upon a smooth floor is examined, the broad impressions made by the heel and the balls of the toes are generally connected on the outer side by a band, which is narrower or broader according to the development of the longitudinal arch. The impression of the entire sole will be made if the bridge of the instep is low, as in *flat-footed* people, while in those whose arched insteps are very high the only impressions thus made correspond to the heel and the balls of the toes, the intervening portions of the sole hardly touching the surface upon the outer side. The half-arches of the two feet when the latter are placed upon the ground as in the attitude of attention may be considered to form a complete transverse arch or dome. This is of no little importance in maintaining the erect position, as it serves as a firm basis of support and equally distributes the weight transmitted through the two legs.

The longitudinal arch is directed a little outward from the axis of the normally-formed foot, and when the foot is planted upon the ground and looked at from above the inner border will be seen to be slightly concave and the outer border convex. In the condition of *flat-foot*, however, the inner border forms a straight line instead of a curve, owing to the sinking of the longitudinal arch, which brings the sole almost to a level. The maintenance of the natural longitudinal arch as well as of the transverse half-arch of the foot is due not only to the conformation of the bones, but also to the peculiar ligaments and tendons on the plantar surface of the foot. With regard to the ligaments in this region, it may be said that their fibres have a general tendency to become cords and form fasciculi rather than expansions such as are characteristic of the ligaments of the hand.

The ankle-joint is formed by the trochlear surface of the astragalus received against the lower end of the tibia and articulating by its two lateral facets with the malleolus of the tibia upon the inner side and with the malleolus of the fibula upon the outer side. It is a ginglymus or hinge joint. The bony surfaces are covered with cartilage and enclosed by a capsular ligament, which is strengthened upon the sides by special lateral ligaments.

The *capsular ligament* is attached above to the front and posterior edges of the articular surface of the tibia, and below to the margin of the upper articular surfaces of the astragalus. It is very weak posteriorly, where it is inseparable from the synovial membrane lining the joint, while anteriorly it is reinforced by some oblique fibres and is separated from the synovial membrane by a quantity of fat. The oblique fibres are particularly developed upon that part of the capsule which extends from the supra-articular ridge on the front of the tibia and the internal malleolus to the front of the neck of the astragalus, this portion of the capsule being sometimes specialized as the *anterior ligament.* When the ankle is strongly flexed the anterior ligament becomes folded transversely, and when it is extended the posterior part of the capsule is similarly folded, but to a lesser degree. The *internal lateral ligament,* or *deltoid ligament,* consists of a double layer of specialized fibres upon the inner side of the capsule. The *superficial layer* extends vertically from the notch on the lower end of the internal malleolus to the contiguous border of the astragalus and the sustentaculum tali of the os calcis, some of the fibres expanding in front to be inserted upon the scaphoid bone and the inferior calcaneo-scaphoid ligament. The *deeper layer* consists of a short, strong band connecting the apex of the internal malleolus with the astragalus below the articular surface. The *external lateral ligament* consists of three special cord-like bands or fasciculi, which have received the following designations: the *anterior astragalo-fibular ligament,* extending from the front of the external malleolus to the outer part of the neck of the astragalus; the *calcaneo-fibular ligament,* passing from the lower end of the external malleolus to the os calcis; and the *posterior astragalo-fibular ligament,*

extending from the depression on the back of the external malleolus to the notch on the posterior surface of the astragalus. The *synovial membrane* lines the capsule in relation to the ankle-joint, and extends a short fold upward between the lower ends of the tibia and the fibula.

The security of the ankle-joint depends upon the great strength of the lateral ligaments. Although the formation of the ankle chiefly allows the foot to be extended or flexed upon the leg, yet it is not so perfect a hinge-joint that the motions are limited to these directions. In extension there is also a slight lateral movement of the foot, which is due partly to the fact that the internal malleolus is shorter than the outer, and partly to the narrower end of the astragalus being in that position brought into the widest part of the intermalleolar notch. It should also be remembered that the ligaments of the inferior tibio-fibular joint, especially the transverse (page 301), do not confine the external malleolus firmly, so that in flexion when the wide part of the astragalus is driven forcibly between the two malleoli, as in a sprain of the ankle, the outer malleolus is raised a little, thereby diminishing the effect of the violence, which would probably more often result in fracture of the fibula if it were not for the spring-like provision of the transverse ligament. Flexion of the ankle is limited by the prominence in front of the neck of the astragalus. The arrangement of the many tendons which surround the ankle-joint also contributes much to its protection: thus, behind in the middle line is the tendo Achillis, upon the outer side and behind the external malleolus are the tendons of the peroneus longus and peroneus brevis muscles, upon the inner side and behind the internal malleolus are the tendons of the flexor longus hallucis, flexor longus digitorum, and tibialis posticus muscles, while in front from within outward are the tendons of the tibialis anticus, extensor hallucis, extensor longus digitorum, and peroneus tertius muscles (Plates 92, 93, and 94).

The *arteries* which supply the ankle-joint are derived from the malleolar branches of the anterior tibial artery (page 309) and peroneal artery (page 317). The *nerves* are branches of the anterior and posterior tibial nerves.

The most important of the *intertarsal joints* are those which the under surfaces of the astragalus form with the os calcis and the scaphoid, which permit of the abduction and adduction of the foot, so useful in walking and in running. The *astragalo-calcanean joint* is provided with a capsule, certain portions of which have been specialized as the *posterior astragalo-calcanean ligament*, which extends from the external tubercle at the back of the astragalus to the upper and inner surface of the os calcis, and the *external astragalo-calcanean ligament*, which extends from the bone in front of the anterior portion of the external lateral ligament to the outer surface of the os calcis. But the strongest of all the connecting bands between the os calcis and the scaphoid is the *interosseous calcaneo-astragaloid ligament*, which consists of a thick band of vertical and oblique fibres occupying the *sinus tarsi*, formed by the juxtaposition of the grooves on the opposing bones, already described (page 323).

The *astragalo-calcaneo-scaphoid joint* is an arthrodial joint. The rounded head of the astragalus rests upon the glenoid surface on the posterior part of the scaphoid bone, and the anterior concave facet on the sustentaculum tali, as well as on the calcaneo-astragaloid ligament, which connects the anterior border of that process with the lower border of the scaphoid bone. The portion of this ligament upon which the head of the astragalus rests is provided with a disk of fibro-cartilage. A few weak fibres passing obliquely from the neck of the astragalus to the upper surface of the scaphoid are called the *superior astragalo-scaphoid ligament.* This joint is provided with an extension of the *synovial membrane* from the anterior calcaneo-astragaloid joint. Dislocation may occur more readily at the astragalo-scaphoid joint than at any of the other independent joints of the foot, owing to the weak nature of its construction.

The *calcaneo-cuboid joint* is provided with a synovial cavity enclosed by a feeble capsule which is reinforced by the following accessory bands: the *superior calcaneo-cuboid ligament*, a narrow band connecting the os calcis and the cuboid on the dorsal surface; the *inferior calcaneo-cuboid ligament*, a broad, strong band extending from the anterior tubercle on the under surface of the os calcis to the contiguous surface and tuber-

osity of the cuboid bone; and the *internal calcaneo-cuboid ligament*, which attaches the inner side of the cuboid bone to the anterior and inner surface of the os calcis. The calcaneo-cuboid joint and the adjacent intertarsal joints are protected upon their plantar surfaces by the *long calcaneo-cuboid* or *long plantar ligament*, which arises from the rough under surface of the os calcis and its tubercles and passes forward, dividing into superficial and deep lamellæ. The superficial layer is the longer, and expands to be attached into the bases of the three outer metatarsal bones, giving origin to the *adductor obliquus hallucis* and other muscles of the sole, besides ensheathing the tendon of the peroneus longus muscle as it passes in the groove on the under surface of the cuboid bone. The deep layer expands to be inserted at the tuberosity and inner border of the cuboid bone. Beneath the superficial layer of the long plantar ligament there are several fasciculi, which have been specialized as the *anterior transverse tarso-metatarsal ligament* and the *posterior transverse intertarsal ligament.*

The *scapho-cuneiform joint* connects the three cuneiform bones with the anterior surface of the scaphoid bone. It is provided with a single capsule lined with *synovial membrane* which is projected between the cuneiform bones and the outer cuneiform and the adjacent cuboid bone, and usually also between the scaphoid and cuboid bones. The fibres forming the dorsal part of the capsule separate into five slips, which pass from the scaphoid, one going to the external cuneiform, two to the middle cuneiform, and two to the internal cuneiform. The plantar portion of the capsule is inseparable from the tendon of the tibialis posticus muscle, prolonging its insertion to the under surfaces of the three cuneiform bones. The joints connecting the cuneiform bones with one another, and the external cuneiform with the cuboid, are further supplied by *interosseous ligaments* consisting of strong transverse fibres, and of many small bands of parallel fibres upon the upper and lower surfaces, called respectively *dorsal* and *plantar ligaments.* There is very little movement between the cuneiform bones, the joint between them and the scaphoid bone being more movable. This, in conjunction with the gliding motion which is permitted at the medio-tarsal line extending across the

astragalo-scaphoid and calcaneo-cuboid joint, contributes to the rotation of the foot, which permits the sole to be turned outward and inward as well as extended and flexed.

The metatarsal bones are five in number, arranged in a closely-united row parallel with one another, and are distinguished according to their position from within outward. In general construction they resemble the metacarpal bones of the hand. Each has a differently wedge-shaped base or tarsal end with a flat articular surface, and a trilateral shaft tapering toward the head or phalangeal end, which is hemispheroidal in shape and constricted laterally for the attachment of ligaments. The *bases* articulate with the tarsal bones by their upper surfaces, and with the contiguous metatarsal bones by their lateral surfaces. The *shafts* are slightly curved longitudinally, presenting, when in position, a convex surface above and a concave surface below. The articular surfaces on the *heads* are oblong from above downward, and extend farther backward upon their plantar surfaces than upon the dorsal surfaces. They are also grooved in the middle line on their plantar surfaces for the flexor tendons of the toes.

The *first metatarsal bone* (or *metatarsal bone of the great toe*) is peculiar for its greater thickness in comparison to its fellows, and for being shorter than they are. Its shaft is remarkably strong, and is prismoid in form, but less compressed laterally than the shafts of the other bones. The base is without lateral articular facets. The surface which is adapted to the internal cuneiform is kidney-shaped, and about its circumference there is a groove for the tarso-metatarsal ligaments. Upon the under surface a rough prominence affords attachment to the tendon of the peroneus longus muscle. The head is remarkably large, and presents on the plantar surface two decided grooves for the sesamoid bones, which are situated here (page 337).

The *second metatarsal bone* is the longest of the series, and when in position its head advances beyond the heads of all the others. Its base or tarsal end is broad above, narrow and rough below, and is received into the peculiar recess formed between the three cuneiform bones. It articulates with the middle cuneiform bone by a triangular facet upon

PLATE 93.

Figure 1.

Dissection of the back of the right leg, showing especially the relations of the superficial veins and nerves.

1. The semi-tendinosus muscle.
2. The semi-membranosus muscle.
3. The sartorius muscle.
4. The small sciatic nerve.
5. The internal popliteal nerve.
6. The tendon of the gracilis muscle.
7. The external saphenous nerve.
8. The internal saphenous vein.
9. The point of entrance of the external saphenous vein into the deep fascia.
10. Cutaneous branches of the internal saphenous nerve.
11. The internal root of the external saphenous nerve.
12. The internal malleolus.
13. The biceps muscle.
14. The external popliteal nerve.
15. Cutaneous branch of the external popliteal nerve.
16. The external root of the external saphenous nerve.
17. The tendo Achillis.
18. The plantar fascia.

Figure 2.

Deep dissection of the sole of the right foot, showing the plantar arterial arches.

1. The posterior tibial nerve.
2. The posterior tibial artery.
3. The internal plantar nerve.
4. The internal plantar artery and its venæ comites.
5. The tendon of the flexor longus digitorum muscle.
6. The tendon of the tibialis posticus muscle.
7. The cut tendon of the tibialis anticus muscle.
8. The tendon of the abductor hallucis muscle.
9. The flexor brevis hallucis muscle.
10. The sixth digital artery.
11. The tendon of the second lumbrical muscle.
12. The os calcis.
13. The cut abductor minimi digiti muscle.
14. The cut flexor brevis digitorum muscle.
15. The tendon of the peroneus longus muscle.
16. The external plantar artery and its venæ comites.
17. The external plantar nerve.
18. The flexor accessorius muscle.
19. The flexor longus digitorum muscle.
20. The nerve to the flexor brevis minimi digiti muscle.
21. The fourth plantar interosseous muscle.
22. The flexor brevis minimi digiti muscle.

Figure 3.

Deep anterior dissection of the left leg, showing the course of the anterior tibial vessels and nerve.

1. The anterior tibial artery and its venæ comites in the upper part of the leg.
2. The tibialis anticus muscle drawn forward.
3. The anterior tibial nerve.
4. The tendon of the tibialis anticus muscle drawn forward.
5. The cut tendon of the extensor proprius hallucis muscle.
6. The dorsalis pedis vessels.
7. The cut tendon of the extensor communis digitorum muscle to the second toe.
8. The extensor longus digitorum muscle drawn outward.
9. The nerve to the extensor longus digitorum and peroneus tertius muscles.
10. The anterior tibial artery and veins in the middle of the leg.
11. The peroneus tertius muscle drawn outward.
12. The anterior peroneal artery.
13. The external malleolus.
14. The external malleolar artery.
15. The anterior tibial nerve on the dorsum of the foot.
16. The extensor brevis digitorum muscle.
17. The cut tendon of the peroneus tertius muscle.

Figure 4.

The superficial veins and nerves on the outer and anterior surfaces of the lower third of the right leg and on the dorsum of the foot.

1. Cutaneous branches of the external popliteal nerve piercing the aponeurotic covering of the gastrocnemius muscle.
2. The musculo-cutaneous nerve
3. The external saphenous vein.
4. The external saphenous nerve.
5. Branch of the external saphenous nerve.
6. Branch of the musculo-cutaneous nerve.
7. The aponeurosis covering the tibialis anticus and other extensor muscles.
8. Communicating vein with the internal saphenous vein.
9. Branch of the musculo-cutaneous nerve.
10. The venous arch on the dorsum of the foot.
11. The anterior tibial nerve.

Fig 1

Fig 2

its proximal surface, with the internal cuneiform bone by the upper part of its internal lateral surface, and with the external cuneiform and middle metatarsal bones by a pair of facets, each of which is usually divided by a vertical ridge, although sometimes this subdivision is not marked.

The *third metatarsal bone* is a little shorter than the second, not extending so far back. Its base is obliquely directed against the external cuneiform bone, and it has two internal lateral facets for the second metatarsal bone and a single external lateral facet for the *fourth metatarsal bone.* The latter has also an oblique base with two internal lateral facets and one external lateral facet. The upper one of the internal facets is for the external cuneiform bone, the lower for the third metatarsal.

The *fifth metatarsal bone* (or *metatarsal bone of the little toe*) has an elongated transverse facet for the cuboid bone. Its head is very small, and its base is characterized by a long, rough tuberosity, which projects outwardly and constitutes a prominent landmark upon the outer side of the foot. The line of the tarso-metatarsal joints is very difficult to remember, and, as it is of special importance with reference to the amputation of Lisfranc, it is carefully described on page 338. The surfaces of the bones entering into the formation of the *tarso-metatarsal joints* are all covered with cartilage and lined with *synovial membrane* in the recent state. The several joints are provided with dorsal, interosseous, and plantar ligaments. The *dorsal ligaments* are strong, flat bands, disposed as follows. The first metatarsal bone is connected with the internal cuneiform bone by a single band, the second metatarsal with the three cuneiform bones by three separate bands, the third metatarsal with the external cuneiform by one band, and the fourth and fifth metatarsals with the cuboid bone by one band for each. The *plantar ligaments* consist of short bands of oblique and longitudinal fibres, and are especially strong in relation to the second and third metatarsal bones. The *interosseous ligaments* are disposed mostly in double bands, one of transverse fibres and the other of oblique fibres. The latter are especially developed in relation to the second metatarsal

bone and its connection with the cuneiform bones. The heads of all the metatarsal bones are loosely connected by the *transverse metatarsal ligament,* which blends with the capsular ligaments of the metatarso-phalangeal joints.

The phalanges of the foot are fourteen in number, as in the hand, there being two in the great toe and three in each of the other toes. They are all shorter than their analogues in the fingers. The *first* or *proximal phalanges* have narrow, laterally-compressed shafts. Their metatarsal ends are concave, with strong lateral tubercles, and their distal ends present trochlear surfaces. The first phalanx of the great toe is the largest, and the others decrease in size gradually in succession to that of the little toe.

The *second* or *intermediary phalanges* are very short, presenting a concave proximal and a convex distal end. Their shafts are generally broader than the shafts of the first row.

The *third* or *ungual phalanges* are shaped somewhat like those of the fingers, but are much smaller. They appear flattened from above downward, and have trochlear bases and semicircular expanded ungual processes for the support of the nails. The ungual phalanx of the great toe is much the largest, the others diminishing successively. Very often in the adult the second and third phalanges of the little toe are found ankylosed. The *metatarso-phalangeal joints, as well as the interphalangeal joints,* are arranged similarly to the corresponding parts of the hand. Each of them is provided with *two lateral ligaments* and a *plantar ligament.* They are all capable of greater dorsal extension than the corresponding joints in the fingers, and can be similarly flexed, abducted, and adducted. During flexion the toes have a decided tendency to converge.

The *synovial membranes* in relation to the tarsal bones are six in number: one in the ankle-joint, one in the posterior astragalo-calcanean joint, one in the astragalo-scaphoid, which sometimes communicates with the ankle, one in the scapho-cuneiform joint, which extends to the three inner tarso-metatarsal joints (page 332), one in the joint between the cuboid and the two outer metatarsal bones, and one in the calcaneo-cuboid joint. In the erect position the weight is borne by the two liga-

ments of the sole of the foot, the calcaneo-cuboid and the calcaneo-scaphoid, which are also called the plantar ligaments. The tenseness and strength of these ligaments, as well as the arched shape of the foot, protect the vessels and nerves from pressure. There are always found two small *sesamoid bones* in the tendon of the flexor brevis hallucis muscle, opposite the metatarso-phalangeal joint of the great toe, and occasionally there are sesamoid bones in the corresponding joints of the second and little toes.

The *landmarks* of the ankle and foot are of considerable topographical importance. The positions of all the bony prominences in this region should be noticed in every degree of extension and flexion, and in cases of injury where there is sufficient swelling to obscure the outline careful comparison should always be made between the corresponding parts of the injured and the sound limb. The subcutaneous position of the malleoli enables the contour of their form to be clearly defined. It will be noticed that the internal malleolus is more prominent than the outer, and that it does not descend so low at the inner ankle as the external malleolus at the outer ankle (Plate 96, Figs. 5 and 6). The point of the latter is twelve millimetres, or about half an inch, lower than the point of the former. The greater breadth from before backward of the internal malleolus is conspicuous. The posterior borders of both malleoli are about on the same plane. It is not possible to distinguish the individual bones of the tarsus in front of the ankle, except in extreme extension, when the anterior part of the trochlear surface and margins of the head of the astragalus can be detected. The greater part of the os calcis can be felt. Two and a half centimetres, or about an inch, vertically below the internal malleolus the lesser tuberosity, or sustentaculum tali, of the os calcis is noticeable. Three centimetres, or about one and a quarter inches, in front of the internal malleolus the tubercle of the scaphoid bone forms a marked prominence. The tendon of the tibialis posticus muscle can be distinguished, especially when the foot is everted, just behind the scaphoid tubercle. The lateral and inferior borders of the internal cuneiform bone, the shaft of the metatarsal bone of the great toe, as well as the

sesamoid bones on the plantar surface of the metatarso-phalangeal joint of the great toe, are all more or less sensible to the touch. On the outer side, two centimetres, or about three-fourths of an inch, below the external malleolus the peroneal tubercle can be felt, with the tendon of the peroneus brevis above it and the tendon of the peroneus longus below it (page 310). The tuberosity of the metatarsal bone of the little toe is always prominent upon the outer border of the foot.

The relative bearing of the *lines* of the various articulations is of practical value. The position of the ankle-joint may be indicated by a transverse line drawn across the anterior surface from a point two and a half centimetres, or an inch, above the end of the external malleolus to a point twelve millimetres, or half an inch, above the end of the internal malleolus. The mid-tarsal joint, formed by the astragalo-scaphoid and calcaneo-cuboid articulations, corresponds to a line drawn across the instep from a point midway between the tuberosity of the metatarsal bone of the little toe and the external malleolus to a point midway between the dorsal eminence of the internal cuneiform bone and the internal malleolus, when the foot is extended. It is well to remember that in all positions of the foot the astragalo-scaphoid joint is immediately behind the scaphoid tuberosity. The line of the tarso-metatarsal joints is complicated by the position of the base of the second metatarsal bone, which extends eight millimetres, or about one-third of an inch, above the joint between the internal cuneiform bone and the metatarsal bone of the great toe. The latter can always be readily ascertained, as well as the corresponding joint between the cuboid and the metatarsal bone of the little toe. For practical purposes, the line of the tarso-metatarsal joints may be considered to extend obliquely across the bridge of the foot between the two latter joints. In amputation at this part of the foot it will always be found most feasible to disarticulate the bones by commencing behind the tuberosity of the metatarsal bone of the little toe (page 366). The metatarso-phalangeal joints are two and a half centimetres, or about an inch, posterior to the webs between the toes. The detection of the latter joints will be facilitated by flexing and extending each independently (page 336).

The frequent occurrence of strains to which the many *tendons* about the ankle are subjected, as well as the peculiar contractions which many of them undergo in the various forms of club-foot (page 356), renders a careful consideration of their relative positions of importance (Plates 92, 93, and 94).

The tendo Achillis is always conspicuous above the heel, and between it and the outer and inner ankle there are always two hollow spaces. On the front of the ankle, when the joint is flexed, the tendons of the extensor muscles become prominent, so that they can be distinguished from one another. They are, from within outward, the tendons of the tibialis anticus, extensor longus hallucis, extensor longus digitorum, and peroneus tertius. Immediately behind the internal malleolus is the tendon of the flexor longus digitorum, and behind that is the tendon of the tibialis posticus muscle. Between the latter and the tendo Achillis is the tendon of the flexor longus hallucis. The tendons of the peroneus brevis and peroneus longus are respectively above and below the peroneal tubercle on the outer side of the os calcis and behind the external malleolus. On the outer part of the dorsum of the foot there is a fleshy mass formed by the extensor brevis digitorum muscle, which is situated beneath the tendons of the extensor longus digitorum. On the outer border of the foot the fleshy mass consists of the abductor and flexor brevis minimi digiti muscles, while that on the inner border is formed by the abductor and flexor brevis hallucis muscles. The plantar fascia can be felt through the sole, particularly when the toes are either strongly flexed or strongly extended.

The *skin* in front of and behind the ankle and over the dorsal surface of the foot is thin and loosely connected with the underlying parts. It is provided with very few hairs and many sweat-glands. Contusions, or uneven pressure from improperly-applied bandages, are peculiarly liable to be attended with excoriations over the malleoli or the dorsum of the foot. At the inner and outer borders of the foot the skin presents various wrinkles, owing to radial bands of connective tissue which attach it to the deep structures. Over the sole of the foot the epidermis is remarkably dense and thick, especially where it covers the heel, the

whole of the outer border of the foot, and the balls of the toes, which are the parts ordinarily subjected to pressure when the foot is in contact with the ground. The skin is thinner along the inner border and in the hollow of the arch of the foot, where it is not so closely attached, and is marked by many wrinkles passing mostly toward the clefts between the three inner toes. Like the skin of the palm of the hand, the skin of the sole of the foot is generally adherent to the parts which it covers. It is also abundantly supplied with sweat-glands in those parts which are not indurated by pressure. The epidermis on the heel is marked by transverse ridges, which correspond to the ridges of the papillæ beneath. The papillary ridges over the ball of the great toe are arranged concentrically. On the outer side the thickened skin is traversed by papillary ridges which curve toward the clefts between the outer toes. Pressure upon the skin of the toes tends to produce hypertrophy of the papillæ in certain localities, so that the epidermis covering them becomes thickened, forming corns.

The *subcutaneous fascia* about the ankle and the foot varies in different parts, being provided with a quantity of loose fat about the tendo Achillis, while over the front of the ankle and the dorsum of the foot it is loose, with but little fat in its meshes. The subcutaneous fascia of the sole is peculiarly developed wherever pressure is received, at the heel, the outer border of the foot, and the balls of the toes. In these situations it is composed of many small fatty lobules enclosed among fibrous connective-tissue bands attaching the skin to the deep fascia. The fat beneath the heel is often two centimetres, or three-quarters of an inch, in thickness. It becomes less developed over the middle portion of the plantar fascia, where the skin and fascia are very intimately associated. Owing to the unyielding nature of the subcutaneous tissue in the sole of the foot, there is little chance for swelling or other external indication of inflammatory affections of the deep structures, whereas upon the dorsal surface the tissue is very loose and prone to œdema. The skin over the entire foot is sensitive, and the microscope shows that there are numerous Pacinian bodies upon the various branches of the cutaneous nerves.

When the skin is carefully removed from the front of the ankle and the dorsum of the foot, the superficial vessels and nerves are exposed in their relations to the tendons.

The *superficial veins* form an arch upon the dorsum of the foot (Plate 93, Fig. 4) over the anterior portions of the metatarsal bones. The superficial venous arch has its convexity directed forward, as on the back of the hand. It receives digital tributaries from the upper surfaces of the toes, and from it veins pass across the foot in different directions, communicating with one another and forming a dorsal plexus, the *rete venosum dorsale pedis.* Upon the inner ankle the arch terminates in the internal or long saphenous vein (page 244), and upon the outer ankle the arch terminates in the short or external saphenous vein (page 303). Valves are usually placed at the junction of the principal branches on the dorsum of the foot.

The *superficial lymphatic vessels of the foot* are disposed chiefly in two groups. Those of the inner group are the larger, and they pass both in front of and behind the internal malleolus and accompany the internal saphenous vein, while the outer group of lymphatics partly ascend in front of the leg and eventually join with the lymphatics from the inner group, the combined trunks emptying into the lymphatic glands of the groin, and others, commencing upon the outer border of the foot, pass behind the external malleolus and accompany the external saphenous vein, to terminate in the glands of the popliteal space.

The *cutaneous nerves of the dorsum of the foot* are derived from the musculo-cutaneous, anterior tibial, and internal and external saphenous nerves. The *musculo-cutaneous nerve* is derived from the peroneal nerve (page 287), behind the head of the fibula, within the substance of the peroneus longus muscle. It pierces the deep fascia at the outer side of the middle of the leg (Plate 93, Fig. 4, No. 2), and, after supplying the peroneus longus and peroneus brevis muscles, divides in the meshes of the superficial fascia into inner and outer branches. The inner branch gives off a *hallucal nerve* which joins the internal saphenous nerve at the inner side of the foot, and a communicating nerve which joins the terminal branches of the anterior tibial nerve at the cleft

PLATE 94.

Figure 1.

Superficial dissection of the plantar region of the left foot. The skin and superficial fascia of the sole are carefully removed to show the strong deep plantar fascia.

1. The plantar lateral digital arteries and nerves of the great toe.
2. The superficial transverse ligament.
3. Branches of the internal plantar artery passing to the clefts between the toes, with the digital nerves from the internal plantar nerve.
4. The plantar fascia.
5. Plantar cutaneous branches of the posterior tibial artery.
6. The os calcis.
7. Lateral digital arteries and nerves.
8. The first digital artery.
9. Branch of the external plantar artery.

Figure 2.

The plantar fascia removed to show the superficial muscles.

1. Tendon of the flexor longus hallucis muscle.
2. Tendon of the abductor hallucis muscle.
3. The internal plantar artery and nerve.
4. The flexor brevis digitorum muscle.
5. Plantar branch of the posterior tibial artery.
6. The os calcis.
7. Digital arteries and nerves.
8. The fourth lumbrical muscle.
9. The flexor brevis minimi digiti muscle.
10. The abductor minimi digiti muscle.
11. The cut origin of the plantar fascia.

Figure 3.

The flexor brevis digitorum muscle is removed.

1. The tendon of the flexor longus hallucis muscle.
2. The cut tendon of the abductor hallucis muscle.
3. The tendon of the flexor longus digitorum muscle.
4. The tendon of the tibialis posticus muscle.
5. The tendon of the flexor longus hallucis muscle.
6. The inner portion of the flexor accessorius muscle.
7. The os calcis.
8. The second lumbrical muscle.
9. The fourth lumbrical muscle.
10. The flexor brevis minimi digiti muscle.
11. Aponeurotic arch over the tendon of the peroneus longus muscle.
12. The outer portion of the flexor accessorius muscle.
13. The cut tendon of the peroneus longus muscle.
14. Triangular space between the two portions of the flexor accessorius muscle.

Figure 4.

Deep dissection of the plantar region. The vessels and nerves are removed.

1. The cut tendon of the flexor longus hallucis muscle.
2. The cut tendon of the abductor hallucis muscle.
3. The flexor brevis hallucis muscle.
4. The adductor hallucis muscle.
5. The tendon of the tibialis anticus muscle.
6. The tendon of the tibialis posticus muscle.
7. The os calcis.
8. The cut tendon of the flexor brevis digitorum muscle to the second toe.
9. The transversus pedis muscle.
10. The flexor brevis minimi digiti muscle.
11. The styloid process of the fifth metatarsal bone.
12. The long plantar ligament.

Figure 5.

Dissection of the inner side of the right foot and ankle.

1. The internal malleolus (of the tibia).
2. The tendon of the tibialis anticus muscle.
3. The commencement of the long saphenous vein.
4. The insertion of the tendon of the tibialis anticus muscle.
5. The tendon of the extensor longus hallucis muscle.
6. Metatarsal bone of the great toe.
7. The tendon of the tibialis posticus muscle.
8. The superior tarsal branch of the posterior tibial artery.
9. The tendon of the flexor longus digitorum muscle.
10. The posterior tibial artery.
11. The posterior tibial nerve.
12. Branch of the posterior tibial artery.
13. The insertion of the tendon of the posterior tibial muscle.

Figure 6.

Dissection of the dorsum of the right foot.

1. The anterior annular ligament.
2. The tendon of the anterior tibial muscle seen through a breach in the annular ligament.
3. The musculo-cutaneous nerve.
4. The flexor brevis digitorum muscle.
5. The tendon of the peroneus tertius muscle.
6. The metatarsal artery.
7. The external saphenous nerve.
8. The tendon to the middle toe.
9. The anterior tibial artery seen through a breach in the annular ligament.
10. The anterior tibial nerve.
11. The dorsalis pedis artery.
12. The internal branch of the musculo-cutaneous nerve.
13. The anterior tibial nerve to the adjacent sides of the great toe and second toe.
14. The tendon of the extensor longus hallucis muscle.

Figure 7.

Dissection of the outer side of the left foot and ankle.

1. The peroneus brevis muscle.
2. The tendons of the extensor digitorum muscle.
3. The anterior annular ligament.
4. The tendons of the peroneus tertius muscle.
5. The external malleolus (of the fibula).
6. The external saphenous nerve.
7. The flexor proprius hallucis muscle.
8. The tendon of the peroneus brevis muscle.

Fig 4

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Fig 6

Fig 5

Fig 7

7

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between the great toe and the second toe. The external branch, after giving off a communicating nerve to the external saphenous nerve at the outer ankle, passes over the dorsum of the foot and divides into *digital nerves*, which supply the skin of the contiguous sides of the second and third, third and fourth, and fourth and fifth toes. The distribution of these digital nerves is variable, but the author has found in the majority of his dissections that they have pursued the course above given.

The *anterior tibial nerve* is also derived from the peroneal nerve. It varies in its position on the front of the leg (page 310), but above the ankle it is usually found external to the anterior tibial artery, with which it passes beneath the anterior annular ligament and proceeds on the dorsum of the foot at the outer side of the dorsalis pedis artery, and finally divides opposite the first digital cleft to supply the skin of the adjacent sides of the great toe and the second toe (Plate 93, Fig. 3, No. 15, and Plate 94, Fig. 6, No. 13). The *internal saphenous nerve* is a branch of the anterior crural nerve (page 259). It is in close relation with the internal saphenous vein on the inner side of the leg (page 302) as far as the internal malleolus, where it continues to supply the skin upon the inner border of the foot and the great toe. As above stated, it is joined by the *hallucal nerve* from the musculo-cutaneous nerve over the dorsum of the foot. The *external saphenous nerve* appears at the outer border of the tendo Achillis in close relation with the external saphenous vein (Plate 93, Fig. 4, No. 4). It curves round behind the external malleolus and is distributed to the skin over the outer border of the foot and the little toe. It communicates with the musculo-cutaneous nerve on the dorsum of the foot.

The *dorsalis pedis artery* is the continuation of the anterior tibial artery (Plate 92, Fig. 1, No. 9, and Plate 93, Fig. 3, No. 6). After issuing from beneath the anterior annular ligament the artery passes over the instep as far as the interval between the first and second toes, where it divides into its terminal branches. The *dorsalis hallucis* artery continues over the first interosseous space and supplies the digital arteries to the sides of the great toe and the inner side of the second toe. The *first interosseous perforating artery*, or the *communicating artery*,

leaves the dorsalis pedis at the first interosseous space close to the base of the second metatarsal bone (Plate 96, Fig. 5, No. 9), and penetrates into the sole of the foot to join the deep plantar arch (page 353). The dorsalis pedis artery is between the deep fascia and the dorsal ligaments over the astragalus, scaphoid, and internal cuneiform bones. It is between the tendon of the extensor longus digitorum and the tendon of the extensor longus hallucis muscle. It is accompanied by *venæ comites*, and the anterior tibial nerve is always at its outer side, close to the tendon of the extensor longus digitorum. The artery gives off a *tarsal branch* near the scaphoid bone, which arches beneath the extensor brevis digitorum muscle toward the outer border of the foot (Plate 93, Fig. 3, No. 16). It supplies the tarsal bones and tarsal joints, and anastomoses with the external malleolar and external plantar and other arteries about the outer ankle. The *metatarsal branch* (Plate 94, Fig. 6, No. 6) passes also beneath the extensor brevis digitorum, arches across the bases of the metatarsal bones, and distributes the *three outer interosseous arteries*, which descend over the interosseous spaces to the clefts of the outer toes, where they divide and form the lateral digital arteries. The outermost interosseous artery supplies the outer side of the little toe. At the proximal ends of the interosseous spaces the interosseous arteries communicate with the plantar arch by the *posterior perforating arteries*, and at the distal ends of the spaces they communicate with the plantar digital arteries by the *anterior perforating arteries*.

In the operation for *ligation of the dorsalis pedis artery* the incision should be made along the border of the inner portion of the extensor brevis digitorum (Plate 93, Fig. 3, No. 6), which is close to the vessel and often overlaps it. The artery, with its companion veins, one on each side of it, is to be found beneath a special expansion of the deep fascia directly over the first intermetatarsal space. The anterior tibial nerve is on its outer side. By keeping directly in the line of the vessel and remembering that it is beneath the extra layer of the deep fascia, the vessel will be readily found: through lack of attention to these points this apparently simple operation is often bungled over.

The *deep fascia* over the dorsum of the foot is a very delicate mem-

brane covering the extensor brevis and interosseous muscles. About the ankle the deep fascia is much stronger, forming the *annular ligaments*, which confine the tendons as they pass from the leg to the foot. The *anterior annular ligament* consists of a firm, unyielding band, arranged in two portions, the upper one of which stretches transversely above the malleoli, and the lower one, connected with the other by a weak expansion, passes obliquely from the internal malleolus across the upper part of the tarsus to be attached on the outer side to the os calcis and the cuboid bone. Upon the inner side of the tarsus a portion of the latter separates below the internal malleolus, and is attached to the scaphoid and internal cuneiform bones and to the plantar fascia. This peculiar disposition of the anterior annular ligament at the ankle has occasioned the upper part to be specialized as the *superior anterior annular ligament*, and the lower part, because its branches on the inner side of the tarsus resemble the Greek letter Λ, the *ligamentum lambdoideum*. From the under surface of the superior anterior annular ligament a septum passes inward, forming a sheath for the tibialis anticus tendon on the inner side, and a sheath for the extensor longus hallucis tendon and the anterior tibial vessels and nerve at the middle of the ankle. Upon the outer side the tendons of the extensor longus digitorum and peroneus tertius muscles are ensheathed by an expansion from the under surface of the outer part of the ligamentum lambdoideum. Each of these sheaths or compartments formed by the anterior annular ligament is lined with a separate synovial bursa, which in the case of the tendon of the tibialis anticus muscle extends considerably higher than the others, the sheath for that tendon being specially included by a splitting of the fibres of the ligament. It is interesting to note that the bursa in relation to the tendon of the extensor longus hallucis is interposed between it and the anterior tibial vessels and nerve, which in this locality are immediately upon the lower end of the tibia.

There are also strong lateral expansions of the deep fascia which are respectively known as the *external* and *internal annular ligaments*. The external extends from the outer malleolus to the os calcis, arching across the tendons of the peronei muscles, in relation to which there is

also a synovial bursa. The internal annular ligament is a more or less developed band which extends from the inner malleolus to the os calcis, blending with the insertion of the plantar fascia at the heel. It serves to confine the tendons of the tibialis posticus, flexor longus digitorum, and flexor longus hallucis muscles as they pass round the inner ankle. A separate compartment, lined with synovial membrane, is formed for each of these tendons by expansions from the under surface of the ligament. The importance of the annular ligaments at the ankle and the synovial bursæ in relation to the tendons which they confine is rarely appreciated until some violent wrench or strain makes evident their function. In such injuries the plastic inflammation which involves the sheaths of the tendons is often followed by chronic impairment of the power and mobility of the foot.

The *extensor brevis digitorum muscle* (Plate 93, Fig. 3, No. 16) arises from the external part of the os calcis, from the external calcaneo-cuboid ligament, and from the adjacent anterior annular ligament, and passes beneath the tendons of the extensor longus digitorum (Plate 92, Fig. 1, No. 15), the fibres taking an oblique course and terminating in four tendons, which are attached to the four inner toes, as follows: the innermost is the largest, and, because it is inserted independently by an expansion into the base of the first phalanx of the great toe, is sometimes considered separately as the *extensor brevis hallucis muscle*, while the outer three tendons unite with the corresponding long extensor tendons (page 306) upon their outer sides (Plate 94, Fig. 6, No. 14), and are inserted with them into the dorsal aponeurosis of the second, third, and fourth toes.

There are seven *interosseous muscles* in the foot, which are arranged very much like the interosseous muscles in the hand. They occupy the intermetatarsal spaces, four being upon the dorsal surface and three upon the plantar. The four *dorsal interosseous muscles* are visible below the divisions of the extensor brevis digitorum. Each of these little muscles, except the first, arises by two heads from the opposed surfaces of the metatarsal bones, their heads being separated by the perforating artery corresponding to each interspace. The *first dorsal interosseous muscle*

arises by an *inner head* from the base of the metatarsal bone of the great toe and from the internal cuneiform bone, often blending with the insertion of the peroneus longus muscle, and by an *outer head* from the second metatarsal bone. It is inserted into the dorsal aponeurosis of the second toe upon the side next to the great toe. The *three plantar interosseous muscles* arise from the inner sides and plantar surfaces of the third, fourth, and fifth metatarsal bones, and are respectively inserted into the bases of the first phalanges and dorsal aponeurosis of the third, fourth, and fifth toes. Bursæ are generally found interposed between the metatarso-phalangeal joints and the tendons of the interosseous muscles. These bursæ sometimes occasion painful swellings between the toes. The interosseous muscles are supplied by the external plantar nerve. The action of the interosseous muscles is chiefly to produce flexion of the toes, although they also serve to draw the toes to or from one another, according to the side of the phalanges upon which they are inserted. The dorsal interossei tend to draw away from the line of axis of the second toe, while the plantar interossei draw toward it.

Upon removal of the skin and superficial fascia from the sole of the foot, the *deep* or *plantar fascia* is exposed. The dissection requires much patience, in consequence of the tough septa of areolar tissue which encloses the peculiar granular fat in this region and which intimately connects the fascia with the skin by numerous strong fibres.

The plantar fascia (Plate 94, Fig. 1, No. 4) is a glistening, white, dense condensation of the deep fascia, composed of transverse and longitudinal fibres. The central portion is the strongest. It is attached posteriorly to the under and back part of the os calcis, and extends forward, spreading out over the heads of the metatarsal bones, where it divides into five slips, each of which expands and separates into several layers. The most superficial of these layers blends with the skin in the depth of the *transverse digital furrow*, which marks off the toes from the sole, while the deeper layers form lateral bands which blend with the capsular ligaments of the metatarso-phalangeal joints and the sheaths of the flexor tendons. Near the os calcis the fibres are chiefly longitudinal, but they are reinforced by transverse fibres as the fascia expands,

and at the points of subdivision the transverse fibres are especially strong, serving to bind the slips together, and forming arches across the digital vessels and nerves, which can be seen, when the fat is removed, passing to the sides of the toes (Plate 94, Fig. 1). Along each side of the central portion of the plantar fascia there are expansions, which are much less dense in front than they are behind. These form the *lateral plantar intermuscular septa,* and serve to separate the muscles of the great toe and little toe respectively from the central mass of muscles in the sole of the foot. When the fat is removed it will be noticed that the margins of the central portion of the plantar fascia are clearly indicated by furrows into which pass the lateral expansions. The outer expansion is strongly developed between the tuberosity of the metatarsal bone of the little toe and the os calcis, and is sometimes called the *fifth metatarsal ligament,* and in consequence of muscular fibres being often found in the band it has received the additional name of the *abductor ossis metatarsi minimi digiti muscle.*

The central portion of the plantar fascia assists materially in supporting the antero-posterior arch of the foot. In "flat-foot" there is always more or less yielding of this fascia. An abscess situated beneath the plantar fascia will always be firmly bound down, and often causes intense pain and great destruction of the deeper tissues unless promptly relieved. Sometimes foreign bodies are retained beneath the plantar fascia and give rise to many obscure symptoms due to irritation of the plantar nerves. In one case the author removed a splinter three inches long from the foot of a young lady, which had penetrated a thin slipper while she was dancing upon a rough floor, and had been retained beneath the plantar fascia for the period of a year and a half. During this time she had been subject to frequent epileptic attacks of a severe character, but, as there had not been any inconvenience in walking, nor any other symptoms referable to the accident to her foot, the local cause was not recognized until demonstrated by its removal, when the epilepsy entirely ceased.

After division of the plantar fascia above the heel, and its careful dissection, the various groups of muscles of the sole of the foot are

exposed, with the branches of the plantar vessels and nerves (Plate 94, Figs. 2, 3, and 4).

The *flexor brevis digitorum muscle* arises from the inner tubercle of the os calcis, between the abductor hallucis and the abductor minimi digiti, from the intermuscular septa, and from the under surface of the plantar fascia. It passes forward and divides into four tendons, which pass to the four outer toes superficially to the tendons of the flexor longus digitorum (page 313), the sheaths of which they enter. At the bases of the first or proximal phalanges the tendons of the flexor brevis divide, allowing the tendons of the flexor longus to pass between them to the bases of the distal or ungual phalanges, while they again unite and are inserted into the second or intermediary phalanges. The manner of the insertion of these tendons is similar to that of the tendons of the flexor sublimis digitorum in the hand (page 381, Vol. I.). When the flexor brevis digitorum is removed, the *main tendon of the flexor longus digitorum* is seen descending from behind the inner ankle into the sole (Plate 94, Fig. 3, No. 3), where it receives a slip from the tendon of the flexor longus hallucis muscle (page 314) and the insertion of the flexor accessorius muscle (as described below), and divides into four tendons, which perforate the tendons of the flexor brevis (as described above) to be inserted into the bases of the ungual phalanges of the four outer toes. The *flexor accessorius muscle* arises beneath the flexor brevis by muscular fibres from the inner and lower part of the os calcis, from the calcaneo-scaphoid ligament, and by tendinous fibres from the external tubercle of the os calcis and the adjacent border of the calcaneo-cuboid ligament. The fibres of the muscle pass directly to the deep border of the long flexor tendon, into which they are inserted by short fibrous bands. The accessorius is chiefly attached to the tendons for the third and fourth toes. When the under surfaces of the tendons of the flexor longus digitorum are examined, they are found to receive upon their opposed sides the attachments of four small muscles, called the *lumbricales* (Plate 94, Fig. 3). Each of these muscles, except the first, which is attached only to the inner side of the tendon to the second toe, arises by two tendons and passes forward around the inner side of

PLATE 95.

Figure 1.

The relations of the parts as they appear after amputation at the right hip-joint, by the long anterior and short posterior flap method.

1. The tendon of the adductor longus muscle.
2. The pectineus muscle.
3. The psoas muscle.
4. The iliacus muscle.
5. The sartorius muscle.
6. The anterior crural nerve.
7. The tensor fasciæ femoris muscle.
8. The anterior portion of the capsule of the hip turned upward.
9. The bottom of the acetabulum.
10. The gluteus medius muscle.
11. A branch of the external circumflex artery.
12. The pyriformis muscle.
13. A branch of the superior perforating artery.
14. The cut femoral artery and vein.
15. The adductor brevis muscle.
16. The profunda femoris artery and vein.
17. The obturator externus muscle.
18. The adductor magnus muscle.
19. The tendon of the biceps femoris muscle.
20. The tendons of the semi-tendinosus and semi-membranosus muscles.
21. The great sciatic nerve.
22. The gluteus maximus muscle.

Figure 2.

Amputation through the middle of the right thigh by the antero-posterior oval flap method, showing the proper relations of the vessels to the femur and the appearance of the severed muscles immediately after the bone has been sawn, in a well-developed man, aged about thirty-two years.

1. The rectus femoris muscle.
2. The periosteal flap turned upward.
3. The shaft of the femur.
4. The vastus externus muscle.
5. Perforating branches of the profunda femoris artery.
6. The great sciatic nerve.
7. The biceps femoris muscle.
8. The tendon of the semi-membranosus muscle.
9. The semi-tendinosus muscle.
10. The internal saphenous vein.
11. The sartorius muscle.
12. The vastus internus and crureus muscles.
13. The femoral artery.
14. The femoral vein.
15. The adductor longus muscle.
16. The adductor magnus muscle.
17. Perforating arteries.

Figure 3.

Amputation at the right knee-joint by the antero-posterior flap method, showing the relations of the severed parts as they appear upon completion of the operation.

1. The ligamentum patellæ.
2. The external condyle.
3. Fatty tissue in the intercondylar fossa.
4. The external lateral ligament.
5. The popliteal vein.
6. Branches of the inferior external articular vessels.
7. The internal popliteal nerve.
8. The external popliteal nerve.
9. The posterior flap, consisting chiefly of the divided gastrocnemius muscle.
10. The internal condyle.
11. The popliteal artery.
12. The inferior internal articular artery.
13. The tendon of the plantaris muscle.

Figure 4.

Amputation at the middle of the right leg, showing especially the proper relations of the vessels.

1. The tibialis anticus muscle.
2. The extensor longus digitorum muscle.
3. The anterior tibial vessels and nerve.
4. The peroneus longus muscle.
5. The sawn fibula.
6. The peroneal vessels.
7. The external saphenous vein and nerve.
8. The sawn tibia.
9. The tibialis posticus muscle.
10. The posterior tibial vessels and nerve.
11. The posterior flap, consisting of the divided soleus and gastrocnemius muscles.

Fig 1

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each of the outer toes respectively, and is inserted into the dorsal aponeurosis, blending with the tendinous insertions of the extensor muscles over the bases of the proximal phalanges.

The action of the flexor brevis digitorum muscle is to flex the second or intermediary phalanges on the first or proximal phalanges, and then to flex the latter on the metatarsal bones. The flexor accessorius muscle serves to correct the obliquity of the main tendon of the flexor longus digitorum which is due to the projection backward of the heel. The action of the lumbricales is very similar to that of the analogous muscles in the hand (page 403, Vol. I.).

There are four short muscles of the great toe, the abductor hallucis, the flexor brevis hallucis, the adductor obliquus hallucis, and the adductor transversus hallucis. The *abductor hallucis muscle* arises from the inner tubercle of the os calcis (Plate 94, Fig. 2, No. 2), from the internal annular ligament and the plantar fascia, and from the septum separating it from the flexor brevis digitorum, thus arching over the plantar vessels and nerves and the tendons which pass round the inner ankle beneath the annular ligament. It also receives an additional origin from the tuberosity of the scaphoid bone. The fibres converge to a tendon which is inserted into the base of the first phalanx of the great toe and the inner sesamoid bone. This muscle is practically the innermost of the series of interosseous muscles of the foot. Its chief action is to flex the first phalanx, while it extends the second, although it is capable of abducting the great toe to a slight degree inward from the middle line of its proper metatarsal bone.

The *flexor brevis hallucis muscle* (Plate 94, Fig. 4, No. 3) arises by a narrow tendon from the cuboid bone and from the fibrous expansion from the tendon of the tibialis posticus muscle into the internal cuneiform bone (page 315). It divides into two portions, which pass over the metatarsal bone of the great toe, one on each side of the tendon of the flexor longus hallucis muscle, and are inserted tendinously into the outer and inner sides of the proximal phalanx of that toe and to the corresponding sesamoid bones. The inner tendon is closely united with the abductor hallucis, and the outer tendon with the adductor hallucis. The

sesamoid bones in relation to these tendons (page 315) form a pulley through which the tendon of the flexor longus hallucis can act freely without being pressed upon, as in walking and running.

The *adductor obliquus hallucis muscle* is a powerful little muscle arising from the bases of the second, third, and fourth metatarsal bones and from the sheath of the peroneus longus muscle. It passes obliquely across the foot, and is inserted conjointly with the tendon of the inner portion of the flexor brevis hallucis into the external sesamoid bone and the outer side of the base of the proximal phalanx of the great toe. It closely resembles the interosseous muscles, the fleshy portion filling the space on the outside of the first metatarsal bones overlapping the plantar arch.

The *adductor transversus hallucis* (or *transversalis pedis*) *muscle* is a narrow, fleshy band extending across the distal ends of the metatarsal bones. It arises by three slips from the plantar surfaces of the capsular ligaments of the fourth and fifth metatarso-phalangeal joints, and passes transversely to be inserted also into the outer sesamoid bone with the above muscles. This muscle forms the base of the so-called *plantar triangle,* in which the plantar arch is formed, the inner side of the space being bounded by the adductor obliquus, and the outer side by the flexor brevis minimi digiti.

There are three muscles of the little toe, the abductor minimi digiti, the flexor brevis minimi digiti, and the opponens minimi digiti. The *abductor minimi digiti muscle* is on the outer side of the foot (Plate 94, Fig. 2, No. 10). It arises from the under surface and outer tubercle of the os calcis, from the plantar fascia, and from the septum between it and the flexor brevis digitorum. It arches over the plantar vessels and nerves as they pass into the sole. A portion of the muscle is attached to the tuberosity of the metatarsal bone of the little toe, while the greater part passes forward to a tendon which is inserted into the outer side of the proximal phalanx of the little toe conjointly with the tendon of the *flexor brevis minimi digiti muscle.* The latter is a very small muscle arising from the base of the metatarsal bone of the little toe and from an expansion of the calcaneo-cuboid ligament. It is in-

serted into the outer side of the base of the proximal phalanx of the little toe. The *opponens minimi digiti muscle* is the name given to the deeper portion of the above muscle, which arises from the sheath of the peroneus longus muscle. It is inserted into the front of the lower surface of the metatarsal bone of the little toe.

The plantar arteries are the terminal divisions of the posterior tibial artery (page 315), from which they arise at a point midway between the os calcis and the inner ankle (Plate 93, Fig. 2, No. 4). The *internal plantar artery* passes forward at first beneath the abductor hallucis, and then in the interval between that muscle and the flexor brevis digitorum as far as the base of the ball of the great toe, where it anastomoses with the digital branch of the dorsalis pedis artery (page 343) in the cleft between the great toe and the second toe. In its course it supplies the contiguous muscles, and occasionally establishes a *superficial plantar arch* by sending a branch across to join the superficial branch of the external plantar artery.

The *external plantar artery* is much larger than the internal. It curves outwardly on the sole of the foot (Plate 93, Fig. 2, No. 16), at first between the os calcis and the abductor hallucis, then between the flexor brevis and the flexor accessorius, as far as the base of the metatarsal bone of the little toe. At this point it turns inward between the flexor brevis muscle and the abductor minimi digiti muscle, and passes deeply into the sole over the plantar interosseous muscles, forming the **deep plantar arch.**

This arch corresponds to the posterior fourth of the metatarsal bones. The external plantar artery, between its origin and the arch, furnishes branches to the skin and fascia over the os calcis, and to the muscles of the sole and of the little toe. From the digital border of the arch the *digital arteries* arise. These vessels communicate by means of the *anterior perforating arteries* with the interosseous arteries on the dorsum of the foot (page 344), through the front part of the three outer intermetatarsal spaces, and, by means of the *posterior perforating arteries* at the back part of the spaces, also with the dorsal interosseous arteries. Beyond this series of inosculations the digital arteries extend to the

clefts between the toes, where they subdivide and supply the contiguous sides of the adjacent toes. The terminal twig of the external plantar artery anastomoses with the digital artery, which supplies both sides of the great toe and the inner side of the second toe and is derived from the first perforating or communicating branch of the dorsalis pedis artery. Each digital lateral branch anastomoses with its fellow-branch, establishing two small arches, one in the pulp of each toe, and one beneath the matrix of the nail. Both plantar arteries have *venæ comites* (Plate 93, Fig. 2).

The *plantar nerves* are the terminal divisions of the posterior tibial nerve (page 319), from which they are derived at the inner ankle externally to the corresponding origins of the plantar arteries (Plate 93, Fig. 2, No. 3). The *internal plantar nerve* is larger than the external. It accompanies the internal plantar artery along the inner part of the sole, distributing cutaneous and muscular branches as well as articular branches to the contiguous joints of the tarsus and metatarsus. Between the abductor hallucis and flexor brevis digitorum muscles it divides into four *digital nerves*, which are distributed as follows. The first digital nerve supplies the inner portion of the flexor brevis hallucis muscle and the skin over the inner side of the great toe. The second digital nerve divides into two branches, one to the internal lumbricalis muscle and the other to the opposed sides of the great toe and the second toe. The third digital nerve supplies the second lumbricalis muscle, and then divides to supply the opposed sides of the second and third toes. The fourth digital nerve is joined by a branch from the external plantar nerve, and is distributed to the opposed sides of the third and fourth toes. The digital nerves send off branches at the terminal or ungual phalanges which wind round to supply the dorsal surfaces. It will be noticed that the manner of distribution of the internal plantar nerve corresponds to the manner of distribution of the median nerve on the palm of the hand (page 416, Vol. I.).

The *external plantar nerve* follows the course of the external plantar artery (Plate 93, Fig. 2, No. 17). It supplies the abductor minimi digiti and flexor accessorius muscles, and then divides into a superficial

and a deep branch. The *superficial* joins the fourth digital nerve from the internal plantar, and sends a branch to the cleft between the fourth and fifth toes, supplying the third and fourth lumbricales muscles, as well as the skin of the opposed sides of the little toe and the fourth toe. Another branch also supplies the interosseous muscles of the fourth intermetatarsal space and the outer side of the little toe. The *deep* branch of the external plantar nerve accompanies the plantar arch into the deeper part of the sole of the foot. It supplies all the interosseous muscles except the fourth, the abductor hallucis, the adductor transversus hallucis, and the outer two lumbricales.

There are remarkably few superficial veins in the sole of the foot, but the *superficial lymphatics* are numerous and form an intricate plexus everywhere in the subcutaneous tissues of the sole. The lymphatic vessels arising from this plexus pass to the borders and dorsum of the foot (already described, page 341).

Wounds involving either of the plantar arteries are always serious, on account of their depth and of the difficulty in reaching the cut vessels in the wound without injuring the surrounding nerves and tendons. There is, however, no other satisfactory way of dealing with hemorrhage of these vessels, because it cannot be effectually checked by ligature of the main supplying arteries, the anterior and the posterior tibial, above the ankle, on account of the free inosculations between the malleolar branches of the peroneal artery (page 317) and the other malleolar arteries and the tarsal branch of the dorsalis pedis artery (page 343), also with the internal calcanean branch of the external plantar artery. In some instances the external plantar artery has been secured by a ligature from the dorsum of the foot after excision of one of the metatarsal bones. In most cases hemorrhage from a wound of the sole may be arrested by elevation of the limb, aided by a broad compress over the wound, with compression at the same time applied upon the main arteries at the ankle; but this procedure does not always answer, and the surgeon will have to observe the rule of securing the bleeding vessels in the wound, where the tissues are so dense that the walls of the vessels are not allowed to contract. In this respect, wounds of the sole of the foot,

of the palm of the hand, and of the scalp bear a close resemblance to one another and require similar treatment.

The *bursa* in relation to the metatarso-phalangeal joint of the great toe frequently becomes enlarged in consequence of the wearing of improperly-shaped shoes, forcing the great toe outwardly into an oblique position, so that the metatarsal joint becomes prominent. The condition is called a *bunion*, and when allowed to continue unrelieved may result in weakness of the great toe, owing to the outward displacement of the tendon of the extensor longus hallucis muscle.

The *bursa* between the tendo Achillis and the upper part of the os calcis (referred to on page 313) sometimes becomes inflamed, and may bulge out laterally on each side of the tendon, thus simulating ankle-joint disease.

Much stress has been laid upon the normal relations of the tendons about the ankle (page 339). As they frequently have to be divided in operations for relief from the various deformities which most commonly occur in this region, called *club-foot,* they should also be examined with especial reference to their abnormal position in these deformities.

In *talipes equinus* the heel is drawn up by the contraction of the muscles of the calf through the tendo Achillis, the patient walking upon the balls of the toes. The foot bends at the medio-tarsal joint, so that the astragalus is displaced more or less downward and projects upon the dorsum. The plantar ligaments and fascia are variably contracted.

In *talipes calcaneus* the toes are drawn upward through the agency of the extensor muscles, and the heel assumes a vertical position, the upper articular surface of the astragalus sometimes extending backward so that it projects beyond the tibia.

In *talipes varus* the heel is drawn up by the tendo Achillis, while the foot is adducted, its inner border being drawn upward by the contraction of both the tibialis anticus and the tibialis posticus muscle. The flexor longus digitorum also exerts a contracting influence upon the sole. The os calcis being drawn upward, the astragalus is displaced downward and forward, presenting its upper articular surface on the dorsum. The foot is twisted transversely at the medio-tarsal joint, so

that the scaphoid is displaced upward, often as far as the internal malleolus, and the cuboid bone is forced into the lowest position in the tarsus. The patient always walks on the outer border of the foot, chiefly upon the outer side of the metatarsal bone of the little toe.

In *talipes valgus* the outer border of the foot is drawn upward, the contracting muscles being the peroneus longus and the peroneus brevis. The astragalus usually projects forward and downward, the scaphoid is depressed, and, the foot being abducted, its outer border is raised. In walking, the weight is received upon the internal malleolus and the scaphoid bone.

There are modifications of these forms of talipes which consist in combinations of the varieties above described, and which are designated according to the parts that are predominantly involved. It should be observed that in *talipes equino-varus* the patient walks chiefly upon the ball of the little toe, while in *talipes equino-valgus* he walks upon the base of the great toe.

The points for *division of the tendons about the ankle* are as follows. The tendo Achillis is usually cut from before backward two and a half centimetres, or about an inch, above the os calcis, the knife being preferably introduced from the inner side, to avoid the posterior tibial vessels and nerve. Care should also be observed not to wound the small or external saphenous vein and nerve, which are close to the border of the tendo Achillis, often low down (Plate 93, Fig. 1). The tendon of the tibialis anticus may be divided from the outer side in front of and below the internal malleolus (Plate 92, Fig. 1). The tendon of the tibialis posticus may be divided between the end of the internal malleolus and the tuberosity of the scaphoid bone (Plate 94, Fig. 5). The tendons of the peronei muscles may be divided between the point of the external malleolus and the tuberosity of the metatarsal bone of the little toe, great care being taken to avoid the external saphenous nerve, which here is in close relation to the tendons (Plate 94, Fig. 7). With regard to the operations for the relief of club-foot, it may be said that, owing to the disappointing results often obtained from subcutaneous tenotomy, it is better in many cases to make a free incision over the

PLATE 96.

Figure 1.

The left knee-joint laid open as in the first stage of amputation at this joint, showing the exact relations of the parts.

1. The position of the top of the patella.
2. The upper portion of the severed ligamentum patellæ.
3. The internal condyle of the femur.
4. The anterior crucial ligament.
5. The internal semilunar fibro-cartilage.
6. The coronary ligament.
7. The lower portion of the severed ligamentum patellæ.
8. The external condyle of the femur.
9. The external lateral ligament.
10. The head of the tibia.
11. The external semilunar fibro-cartilage.

Figure 2.

The relations of the parts as seen after completion of an amputation at the left knee-joint by the antero-posterior flap method.

1. The upper portion of the severed ligamentum patellæ.
2. The internal condyle of the femur.
3. The ligamentum mucosum.
4. The internal lateral ligament.
5. Fat in the popliteal space.
6. The popliteal artery.
7. The internal popliteal nerve.
8. The popliteus muscle.
9. The inner head of the gastrocnemius muscle.
10. The external condyle of the femur.
11. The internal semilunar fibro-cartilage.
12. The semi-membranosus muscle.
13. The popliteal vein.
14. The outer head of the gastrocnemius muscle.

Figure 3.

The relations of the parts as seen immediately after amputation at the right ankle-joint by the method of Pirogoff.

1. The cut end of the tendon of the extensor proprius hallucis muscle.
2. The cut tendon of the extensor communis digitorum muscle.
3. The cut tendon of the peroneus tertius muscle.
4. The sawn end of the fibula.
5. The cut tendon of the flexor longus hallucis muscle.
6. The tendons of the peroneus longus and brevis muscles.
7. The section of the os calcis (peculiar to this operation).
8. The external plantar artery and nerve.
9. The skin and fascia of the sole of the foot.
10. The cut tendon of the tibialis anticus muscle.
11. The anterior tibial artery.
12. The sawn end of the tibia.
13. The cut tendon of the tibialis posticus muscle.
14. The posterior tibial artery.
15. The internal plantar artery and nerve.

Figure 4.

The relations of the parts as seen upon removal of the left foot at the medio-tarsal joint, usually called Chopart's operation.

1. The cut tendon of the tibialis anticus muscle.
2. The dorsalis pedis artery.
3. The astragalus.
4. The internal plantar artery.
5. The cut tendon of the abductor hallucis muscle.
6. The external plantar nerve.
7. The cut tendon of the extensor proprius hallucis muscle.
8. The cut tendon of the extensor communis digitorum muscle.
9. The os calcis.
10. The cut tendon of the peroneus longus muscle.
11. The external plantar artery.

Figure 5.

The tarso-metatarsal joint of the right foot laid open, as seen in the first stage of amputation at this joint by the process of Lisfranc.

1. The external malleolus.
2. The external cuneiform bone.
3. The cuboid bone.
4. The external plantar artery.
5. The articular surface of the fifth metatarsal bone.
6. The fourth metatarsal bone.
7. The third metatarsal bone.
8. The internal malleolus.
9. The dorsalis pedis artery.
10. The middle cuneiform bone.
11. The internal cuneiform bone.
12. The flexor tendons in the plantar surface of the foot.
13. The first metatarsal bone.
14. The second metatarsal bone.
15. The severed extensor tendons to the toes.

Figure 6.

The relations of the parts on completion of the amputation (of Lisfranc) at the tarso-metatarsal joint of the right foot, as in Figure 5.

1. The external malleolus.
2. The severed extensor tendons.
3. The external cuneiform bone.
4. The cuboid bone.
5. The external plantar artery.
6. The internal malleolus.
7. The dorsalis pedis artery.
8. The middle cuneiform bone.
9. The internal cuneiform bone.
10. The flexor tendons in the plantar flap.

Figure 7.

The incisions for amputation of the great toe of the left foot, and the relation of the plantar branch of the dorsalis pedis artery to the first metatarso-phalangeal joint.

1. The plantar branch of the dorsalis pedis artery.
2. The base of the proximal phalanx of the great toe.
3. The tendon of the extensor longus hallucis muscle.

Figure 8.

The incisions for amputation of the middle toe of the left foot at its tarso-phalangeal joint.

1. The digital artery in the cleft between the second and third toes.
2. The base of the proximal phalanx of the middle toe.
3. The head of the middle metacarpal bone.

contracted parts, so that the operator can see what he is doing, and therefore do it well. There are always many false bands of condensed connective tissue in these cases, which are almost as important to divide as the contracted tendons, and the orthopædic surgeon who has had experience appreciates the necessity of dividing everything which offers resistance to the foot being placed in proper position. It is an established fact that severed tendons will reunite even when the breach between the cut ends is of considerable extent, provided that their synovial sheaths are not implicated. On account of this last important factor, the tendons in club-foot operations are now usually cut at their insertions by free incisions made in the sole of the foot, rather than above the malleoli, where the synovial sheaths enclose the tendons. It should be noted that a moderate degree of *varus* is natural to the feet of all infants, for the feet are always placed with their soles turned inward and upward while *in utero*, and it is not until the extensor and abductor muscles become more developed that the subsequent normal position of the feet at right angles to the legs is attained.

The peculiar deformity called *flat-foot* is due to the yielding of the calcaneo-scaphoid and long and short calcaneo-cuboid or plantar ligaments, the plantar fascia, and the tendinous insertions of the tibialis anticus, tibialis posticus, and peroneus longus muscles. The calcaneo-scaphoid ligament and the tendon of the peroneus longus are probably those which are most concerned, for they are the chief agents in maintaining the normal arches of the foot. When the inferior calcaneo-scaphoid ligament (page 331) yields, the head of the astragalus is no longer supported, and, as it serves as the keystone of the longitudinal arch, the weight of the body causes a general settling of the tarsal bones, which, becoming affected by undue pressure, gradually change their form and produce various distortions. In all these deformities involving the bones of the tarsus it will be noticed that they occur chiefly about the medio-tarsal joint, which is composed of the astragalo-scaphoid and calcaneo-cuboid joints. In addition to flexion and extension, this joint permits of a slight degree of rotation by which the sole may be turned either inwardly or outwardly, according as the astragalo-

scaphoid or the calcaneo-cuboid joint is chiefly employed. Movement is somewhat freer at the former of these joints than at the latter (page 331).

Dislocations at the ankle-joint are almost invariably associated with a fracture of either the tibia or the fibula, or of both of these bones. The dislocation may occur forward, backward, inward, or outward, and in some rare instances has been reported to have occurred upward, the astragalus having been jammed between the lower ends of the leg-bones. The lateral dislocations are the most common, and are caused by a wrench to the foot in such a manner that the astragalus is rotated so that either the outer or the inner border of its upper articular surface is brought in contact with the horizontal articular surface of the tibia. In such an injury there is necessarily some rupture of the lateral ligaments, but very rarely are the ligaments of the inferior tibio-fibular joint torn. The fibula is the bone which is usually implicated, and it may be broken by either forcible eversion or inversion of the foot (page 320), but most commonly it is by eversion. In the latter form of accident the internal lateral ligament is torn, and the astragalus is brought against the end of the external malleolus, the fibular shaft being usually broken about two or three inches above the ankle. When dislocation occurs from forcible inversion of the foot, the external lateral ligament is stretched, not torn, so that the end of the outer malleolus is drawn inward and the shaft breaks about two or three inches above the ankle. In fracture of the fibula from eversion the lower fragment is inclined toward the tibia, while in fracture from inversion the lower fragment is inclined away from the tibia. In both instances the causes which may be assigned for the breaking of the fibula are the greater comparative length of the outer malleolus and the firm bond between the lower ends of the leg-bones through the strong ligaments of the inferior tibio-fibular joint (page 299).

Pott's fracture at the ankle consists in the dislocation outwardly, with fracture of the lower part of the shaft of the fibula, and rupture of the internal lateral ligament, usually the end of the internal malleolus being broken off. There is generally great deformity, the astragalus being so displaced that the foot is turned completely outward and upward.

Fractures of the bones of the foot are generally occasioned by severe crushes, and are associated with laceration of the skin, fasciæ, and tendons. The os calcis is more frequently broken than any of the other tarsal bones. Sometimes the posterior projection is broken by a fall directly upon the heel, and occasionally it has been detached by the over-exertion of the muscles of the calf upon the tendo Achillis in attempting to recover from a misstep.

The sustentaculum tali has been broken in at least two cases within the author's experience. In one of these the fracture was caused by a fall upon the bare foot, when the process came forcibly in contact with a projecting stone. In the other the patient was thrown from a carriage and probably had the foot violently twisted outward, it having been caught between the spokes of a wheel.

Amputation at the ankle-joint is usually done by one of the two following methods. *Syme's amputation* consists in the removal of the entire foot. A curved incision is first made with a stout straight bistoury from one malleolus to the other, across the instep, with the foot slightly extended. The anterior portion of the capsule of the ankle-joint is at once opened, and the lateral ligaments are divided with the point of the knife. To do this expeditiously, the foot should be depressed and bent outwardly, so as to stretch the internal ligament while it is being cut, and bent inwardly for the same reason while the external ligament is being cut. Care should be taken not to wound the posterior tibial artery, which is immediately behind the internal malleolus (Plate 94, Fig. 5, No. 10). After the superior articular surface of the astragalus is freely exposed, the foot should be brought to its proper position, and a second incision should be made, at an angle of about forty-five degrees with the first, through the tissues of the sole, extending from one malleolus to the other. The dissection of the os calcis from the coverings which are so intimately connected with it at the sides as well as posteriorly is necessarily very tedious, and it can be best done by working alternately from above and from below. It is important to avoid leaving any of the periosteum of the os calcis in the flap, as its presence might occasion the formation of bony nodules which would

produce troublesome irritation in the stump. The ends of the malleoli and the articular surface of the tibia are usually sawn off before bringing the tissues of the heel forward over the bones. The cup-shaped posterior flap resulting from the dissection of the os calcis is liable to form a pocket for the collection of sanious exudation or of pus, and therefore immediately upon the formation of the flaps and before approximating them it is well to make a hole through the most dependent part and insert a tube or some other means of drainage. The vitality of the posterior flap depends on the calcanean branches of the posterior tibial, the malleolar branches of the anterior tibial, and the posterior branches of the peroneal. The stump resulting from a Syme amputation is generally serviceable, but in the author's experience it has not proved so well adapted for support as the stump which results after the modified form of the operation known as the amputation of Pirogoff.

Pirogoff's amputation consists in removing all of the foot except the posterior projection of the os calcis (Plate 96, Fig. 3). The incisions for the flaps are made in precisely the same manner as in the former operation, but, instead of dissecting the heel-flap from the bone after the ankle-joint is opened and the lateral ligaments have been cut, the os calcis is sawn off by applying a narrow-bladed saw behind the posterior lip (or *os trigonum*, page 323) of the astragalus and sawing through the bone in a direction obliquely downward and forward. The object of sawing the os calcis in this manner is twofold: the posterior tibial artery is usually thus preserved in its immediate relation to the bone, and the shape of the section of the bone renders it well adapted to being placed in the former site of the astragalus between the malleoli. It is rarely necessary to saw off the ends of the malleoli, but their articular cartilages as well as the articular cartilage of the lower end of the tibia should be removed, as union between them and the section of the os calcis will thereby be facilitated. It is advisable to divide the tendo Achillis subcutaneously before completing this operation; for, although the section of the os calcis may at first fit nicely in place, subsequent contraction of the muscles of the calf is almost unavoidable, and the consequent tension of the tendo Achillis will necessarily separate the

bones. The relations of the parts as they are found divided in Pirogoff's amputation at the right ankle-joint are shown in Plate 96, Fig. 3. In the dorsal flap there are, besides the skin and fascia, the cut tendons of the tibialis anticus, extensor communis digitorum, extensor longus hallucis, and peroneus tertius muscles, the anterior tibial vessels and nerve, the musculo-cutaneous nerve, and the internal saphenous vein and nerve. In the heel flap, besides the skin and fascia, there are the external saphenous vein and nerve, the tendons of the peroneus longus, peroneus brevis, tibialis posticus, flexor longus digitorum, flexor brevis digitorum, abductor hallucis, adductor minimi digiti, and flexor accessorius muscles, and the plantar vessels and nerves.

Amputations at the instep, or, as they are usually called, *partial amputations of the foot*, are not always successful in obtaining permanently useful stumps for the laboring classes. Every hospital surgeon has this fact emphasized by the number of cases which require re-amputation. This is due partly to the inadequacy of the curtailed member, partly to the strain and pressure after the arches of the foot have been lost, and partly to the impaired or altered vitality of the tissues, which renders them peculiarly liable to excoriation, often producing intractable ulceration.

It is unquestionably proper to save all that will probably be of service in so important a member as the foot, and in no department of conservative surgery have there been more brilliant achievements; but these achievements are questionable from the point of view of utility, for although there are instances in which the partial foot would seem to fulfil its purpose almost as well as the entire foot, and perhaps better than any artificial contrivance, yet these cases are outnumbered by those which sooner or later require re-amputation higher up.

There have been devised many ingenious methods of partial amputation, among which the following are those commonly practised. They are described here only to illustrate the practical application of the anatomy of the foot, an accurate knowledge of which is necessary for their performance. The author has practised all of them many times, and in earlier days shared with others the pride which seemed to be justified by the first result of his cases. Subsequent observation of many

PLATE 97.

A topographical survey of the abdomen of a well-developed adult female, showing the various subdivisions of this region for the clinical study of the relations of the organs and viscera; also showing the relations of the bones of the pelvis and hip to the surface on the right side, and the areas of distribution of the lateral cutaneous nerves on the left side.

1. The right nipple.
2. The ensiform cartilage.
3. The cartilage of the right seventh rib.
4. The probable position of the pyloric extremity of the stomach.
5. The cartilage of the right eighth rib.
6. The lower border of the liver.
7. The position of the right kidney.
8. The umbilicus.
9. The position of the cæcum.
10. The anterior superior spine of the right ilium.
11. The great trochanter of the right femur.
12. The left nipple.
13. The left sixth rib.
14. The left sixth lateral cutaneous nerve.
15. The left seventh lateral cutaneous nerve.
16. The left eighth lateral cutaneous nerve.
17. The position of the left kidney.
18. The left ninth lateral cutaneous nerve.
19. The left tenth lateral cutaneous nerve.
20. The left eleventh lateral cutaneous nerve.
21. The left twelfth lateral cutaneous nerve.
22. The anterior superior spine of the left ilium.
23. The left ilio-hypogastric nerve.
24. The left ilio-inguinal nerve.
25. The position of the sigmoid flexure of the colon.
26. The normal position of the fundus of the uterus.
27. The symphysis pubis.
28. The position of the femoral opening (or ring).

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Photographed and drawn from Nature by George McClellan M.D

Armstrong & Co. Lith Boston

of these cases has, however, convinced him that as a teacher he should discourage the performance of any operation which is not likely to be of lasting benefit to the patient.

Chopart's operation consists in a disarticulation at the medio-tarsal joint, which is formed by the astragalo-scaphoid and calcaneo-cuboid joints (page 338). A curved incision, with its convexity toward the toes, is made across the instep, beginning at the tuberosity of the scaphoid bone two and a half centimetres, or about an inch, in front of the internal malleolus, and extending to a point midway between the external malleolus and the tuberosity of the metatarsal bone of the little toe. The dorsal flap is dissected back two centimetres, or about three-fourths of an inch, and the joint opened by entering the knife first between the scaphoid and the astragalus and then between the cuboid and the os calcis. The sole flap is best made by using the knife from without inward. The incision should begin at the inner angle of the dorsal incision, at the tuberosity of the scaphoid, and extend along the inner border of the sole as far as the middle of the metatarsal bone of the great toe. It should then be carried across in an oval manner two and a half centimetres, or about an inch, in front of the tuberosity of the metatarsal bone of the little toe, and thence along the outer border of the sole to the outer angle of the dorsal incision. In this way the sole flap will be properly fashioned to adapt itself to the greater vertical depth of the inner part of the foot.

The relations of the parts after this operation upon the left foot are shown in Plate 96, Fig. 4. In the dorsal flap there are, besides the skin and fascia, the cut tendons of the extensor communis digitorum, extensor brevis digitorum, extensor longus hallucis, tibialis anticus, peroneus tertius, and peroneus brevis muscles, the musculo-cutaneous, anterior tibial, and long and short saphenous nerves, the dorsalis pedis artery and its *venæ comites*, and the dorsal plexus of veins. In the sole flap there are, besides the skin and fascia, the cut plantar fascia, the tendons of the flexor brevis digitorum, abductor hallucis, adductor minimi digiti, peroneus longus, flexor accessorius, and tibialis posticus muscles, and the plantar vessels and nerves.

Lisfranc's operation (Plate 96, Fig. 5) consists in the removal of the anterior portion of the foot at the line of the tarso-metatarsal joints (page 338). A curved incision, with its convexity toward the toes, is made across the dorsum of the foot from the point of the internal cuneiform bone to the tuberosity of the metatarsal bone of the little toe. The dorsal flap is dissected back two centimetres, or about three-fourths of an inch, and reflected upon the instep. The knife is entered behind the tuberosity of the metatarsal bone of the little toe. By depressing with the left hand the portion of the foot to be removed, the dorsal ligaments are put upon the stretch and will yield more readily to the knife, which should be held perpendicularly and first carried across the line of the joints between the three outer metatarsal bones and the cuboid and external cuneiform bones. It will be arrested by the projection of the tarsal end of the second metatarsal bone, which is received into the notch formed by the cuneiform bones (page 327). The interosseous ligament between the internal cuneiform bone and the second metatarsal bone is especially strong, but will offer little resistance if the foot is forcibly depressed while the point of the knife is inserted between the bones. The joint between the internal cuneiform and the first metatarsal bone is in a straight line about half-way between the ankle and the ball of the great toe.

It has already been observed (page 338) that for practical purposes the line of the tarso-metatarsal joints may be considered to extend obliquely across the bridge of the foot from the joint between the metatarsal bone of the little toe and the cuboid bone to the joint between the metatarsal bone of the great toe and the internal cuneiform bone. In amputation at this line it will always be found easiest to disarticulate the bones by commencing behind the tuberosity of the metatarsal bone of the little toe rather than at the inner side of the foot, owing to the base of the metatarsal bone of the second toe being only four millimetres, or one-sixth of an inch, above the line of the contiguous outer joint, whereas it is eight millimetres, or one-third of an inch, above the line of the contiguous inner joint. The appearance of the severed structures upon the completion of the disarticulation of the

bones before the anterior part of the foot has been removed is well shown in Plate 96, Fig. 5. The sole flap is best made after the manner suggested for Chopart's operation, by using the knife so as to cut from without inward. The incision should extend as far as the ball of the great toe, and not quite so far as the ball of the little toe, upon the inner and outer sides of the sole respectively. It should be remembered that it is necessary that the inner part of the sole flap should be longer than the outer, as the surface of the internal cuneiform bone which has to be covered is greater than that of the cuboid bone which has to be covered. The relative positions of the parts divided upon the completion of the operation of Lisfranc are shown in Plate 96, Fig. 6. They are the same as the structures divided in Chopart's operation in both the dorsal and the sole flap, except that in the latter the tendons of the flexor accessorius and tibialis posticus are not cut. The bleeding vessels are branches of the plantar arteries. It should be noted that the main trunk of the external plantar artery crosses the bases of the metatarsal bones forming the plantar arch (page 353), and, if the knife is not carried too close to the bones in the depth of the wound, will not necessarily be cut. The communicating artery between the plantar arch and the dorsalis pedis artery is very close to the upper part of the intermetatarsal space between the second and third toes, and sometimes gives rise rise to troublesome bleeding.

The *development of the bones of the foot* occurs at the following periods. All the tarsal bones, except the os calcis, have one centre of ossification. The os calcis has a posterior epiphysis which appears during the tenth year and unites with the rest of the bone about puberty. The order in which the tarsal bones ossify is as follows: the body of the os calcis in the sixth week of fœtal life, the astragalus in the seventh month, the cuboid in the ninth month, the external cuneiform in the first year, the internal cuneiform in the third year, the middle cuneiform in the fourth year.

The metatarsal bones and the phalanges have each two centres of ossification. The shaft-centres appear about the ninth week, and ossification extends toward each extremity. The metatarsal bones, except that

he great toe, have the epiphyses at the distal end. They appear lifferent periods between the fifth and the eighth year, and they join r shafts at the twenty-first year. The metatarsal bone of the great is peculiar for having the epiphysis at the proximal end, although sionally there is found a trace of separate bony formation at the ıl end. The proximal epiphysis appears during the third year, and onsolidates with the shaft between the eighteenth and the twentieth ·. The epiphyses of all the phalanges are at the proximal or meta-al ends.

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